PB84-114172

Nationwide Urban Runoff Program, Milwaukee Wisconsin. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County Wisconsin. Volume 2. Feasibility and Application of Urban Nonpoint Source Water Pollution Abatement Measures

Wisconsin Dept. of Natural Resources, Madison

Prepared for

Environmental Protection Agency, Chicago, IL

1983

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No. PB84-114172

4. Title and Subtitle
Nationwide Urban Runoff Program, Milwaukee, Wisconsin, Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, VOLUME 2 (title continued in item 15)

5. Report Date
1983

6.

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8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Wisconsin Department of Natural Resources
P.O. Box 450
Madison, WI 53701

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)P005432

12. Sponsoring Organization Name and Address
EPA, Office of Water Program Operations
Water Planning Division
401 M Street, SW
Washington, D C 20460

13. Type of Report & Period Covered
Final, July 79 - 83

14.

15. Supplementary Notes This document is one of four, which make up the complete final report.
TITLE: VOLUME 2: FEASIBILITY AND APPLICATION OF URBAN NONPOINT SOURCE WATER POLLUTION ABATEMENT MEASURES.

16. Abstract (Limit: 200 words)
This volume evaluates the feasibility, costs, and pollutant removal effectiveness of street sweeping, stormwater detention and retention basins, and catch basins, and catchbasin cleaning. The applicability of these measures is demonstrated for three watersheds in southeastern Wisconsin. The level of pollution loading reduction achieved by street sweeping is relatively modest. Sweeping is most effictive in spring and in fall, and in high density urban developments. Relatively high levels of pollutant removal can be achieved by retention basins or modified detention basins. The use of these basins was generally found to be more cost effective than increased street sweeping.

17. Document Analysis a. Descriptors

Hydrology	Water pollution	Storms	Civil Engineering
Urban development	Water resources	Regional planning	
Watersheds	Sedimentation	Urban planning	

b. Identifiers/Open-Ended Terms

Runoff	Soil Erosion	Storm Drains
Streamflow	Water Quality	Urbanization
Stream pollution	Sediments	Land use
Rainfall	Sediment Transport	
Snowmelt	Suspended Solids	

c. COSATI Field/Group

18. Availability Statement: No restriction on distribution.
Available from National Technical Information Service, Springfield, VA 22161

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
130

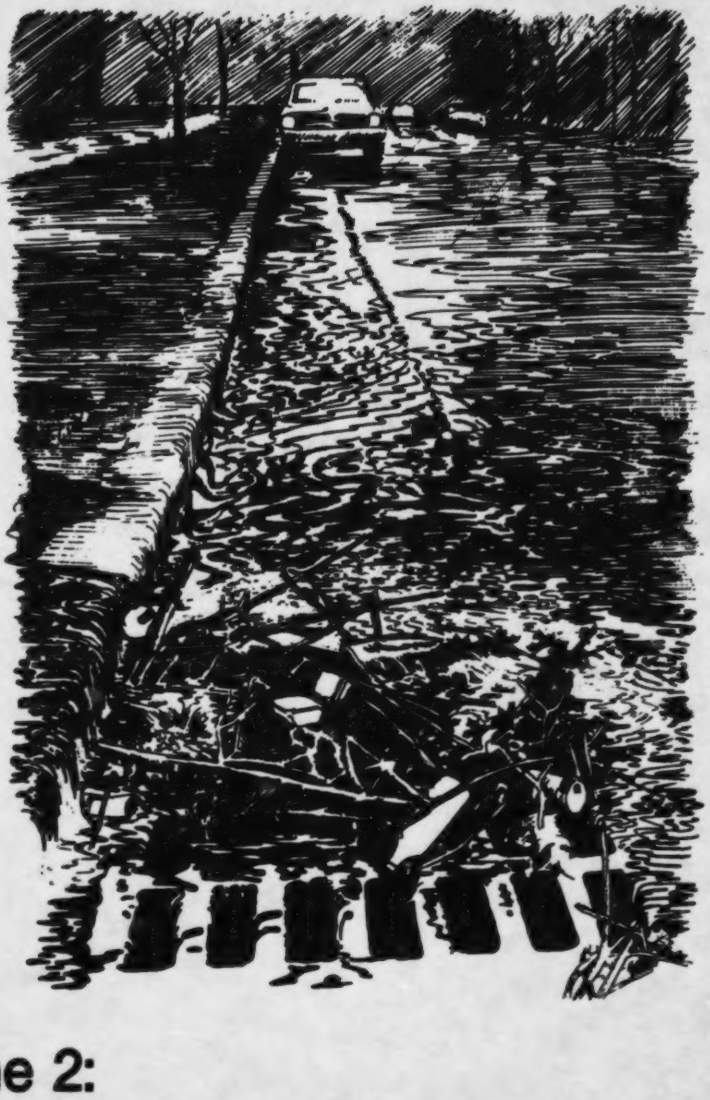
22. Price

(See ANSI–Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4–77)
(Formerly NTIS–35)
Department of Commerce

PB84-114172

Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin



Volume 2:
Feasibility and Application of Urban Nonpoint Source Water Pollution Abatement Measures

Wisconsin Department of Natural Resources
Madison, Wisconsin
1983

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U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

PB84-114172

EVALUATION OF URBAN NONPOINT SOURCE POLLUTION MANAGEMENT IN MILWAUKEE COUNTY, WISCONSIN

VOLUME II

FEASIBILITY AND APPLICATION OF URBAN NONPOINT SOURCE WATER POLLUTION ABATEMENT MEASURES

By

Southeastern Wisconsin Regional Planning Commission
in Cooperation with the
Wisconsin Department of Natural Resources
for
U.S. Environmental Protection Agency

Grant Number P005432-01-5

i.a

DISCLAIMER

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PREFACE

This volume evaluates the feasibility, costs, and pollutant removal effectiveness of street sweeping, stormwater detention and retention basins, and catch basin cleaning. The applicability of these measures is demonstrated for three watersheds in southeastern Wisconsin. The level of pollutant loading reduction achieved by street sweeping is relatively modest. Sweeping is most effective in spring and in fall, and in high density urban developments. Relatively high levels of pollutant removal can be achieved by retention basins or modified detention basins. The use of these basins was generally found to be more cost effective than increased street sweeping.

Volume II

Contents

Page

CHAPTER I. INTRODUCTION

INTRODUCTION I-1
PURPOSE AND SCOPE I-2

CHAPTER II. SUMMARY AND CONCLUSIONS

INTRODUCTION II-1
STREET SWEEPING II-1
STORMWATER STORAGE BASINS II-2
CATCH BASIN CLEANING II-3
EVALUATION OF ALTERNATIVES II-4
CONCLUSIONS II-6

CHAPTER III. FEASIBILITY OF URBAN NONPOINT SOURCE CONTROL MEASURES

INTRODUCTION III-1
DEVELOPMENT OF AN URBAN NONPOINT SOURCE CONTROL PROGRAM III-1
STREET SWEEPING III-2
  Description III-2
  Objectives III-2
  Applicability III-2
  Size of Operation III-3
  Problems III-5
  Pollution Abatement Effectiveness III-8
  Administration and Management III-8
DETENTION AND RETENTION BASINS III-9
  Description III-9
  Objectives III-12
  Applicability III-12
  Size of Operation III-16
  Problems III-17
  Pollution Abatement Effectiveness III-19
  Administration and Management III-21
CATCH BASINS III-23
  Description III-23
  Objectives III-25
  Applicability III-25
  Size or Extent of Operation III-25
  Problems III-26
  Pollution Abatement Effectiveness III-26
  Administration and Management III-27

CHAPTER IV. ECONOMIC ASPECTS OF URBAN NONPOINT SOURCE POLLUTION CONTROL

INTRODUCTION IV-1
STREET SWEEPING IV-1
DETENTION AND RETENTION BASINS IV-8
CATCH BASINS IV-12

CHAPTER V. EVALUATION OF ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR SELECT URBAN AREAS OF SOUTHEASTERN WISCONSIN

INTRODUCTION V-1
NOYES CREEK V-3
  Description V-3
  Water Quality V-3

Description of Alternative Nonpoint Source Control Measures.. V-11
Evaluation of Alternatives V-11
Pollutant Removal V-13
Cost V-13
Cost Effectiveness V-16
Conclusions V-16
UPPER ROOT RIVER WATERSHED V-18
Description V-18
Water Quality V-18
Description of Alternative Nonpoint Source Control Measures.. V-24
Evaluation of Alternatives V-26
Pollutant Removal V-27
Cost V-27
Cost Effectiveness V-30
Conclusions V-30
LINCOLN CREEK WATERSHED V-32
Description V-32
Water Quality V-32
Description of Alternative Nonpoint Source Control Measures.. V-38
Evaluation of Alternatives V-41
Pollutant Removal V-41
Cost V-41
Cost Effectiveness V-44
Conclusions V-44

CHAPTER VI. PUBLIC PARTICIPATION

INTRODUCTION VI-1
COORDINATION WITH PUBLIC OFFICIALS VI-1
PERSONAL CONTACTS VI-1
INFORMATIONAL BROCHURES VI-2
PUBLIC EVENTS AND PRESENTATIONS VI-2
USE OF THE MEDIA VI-3
PROFESSIONAL EXCHANGE VI-3
FINAL PUBLIC PARTICIPATION PRODUCTS VI-4
REFERENCES ....

FIGURES

Number | Page

CHAPTER III

III.1 Effect of Vehicle Parking on Street Sweeping III-7
III.2 Schematic Diagram of a Typical Detention Basin and Retention Basin III-13
III.3 Schematic Diagram of Modifications to Detention Basins to Improve Their Pollutant Removal Effectiveness III-14
III.4 The Pollutant Removal Effectiveness of Retention Basins in the Great Lakes Area III-20
III.5 Typical Stormwater Catch Basin III-24

CHAPTER IV

IV.1 Capital Cost Curve for Modified Detention Basins IV-10

MAPS

CHAPTER V

V.1 Existing Land Use for the Noyes Creek Watershed: 1980 ..... V-5
V.2 Existing Street Sweeping Program for the Noyes Creek Watershed V-6
V.3 Existing Land Use in the Upper Root River Wateshed: 1980 .. V-19
V.4 Alternative Nonpoint Source Control Measures for the Upper Root River Watershed V-20
V.5 Existing Land Use in the Lincoln Creek Watershed: 1980 .... V-33
V.6 Alternative Nonpoint Source Control Measures for the Lincoln Creek Watershed V-34

TABLES

Number Page

CHAPTER II

II.1 Comparison of Urban Nonpoint Source Control Alternatives for the Study Watersheds II-5

CHAPTER III

III.1 Nationwide Survey of Average Municipality Areas, Curb Length, and Street Sweeper Operations III-4
III.2 Interferences to Effective Street Sweeping III-6
III.3 Methods of Maximizing the Pollutant Removal Effectiveness of Street Sweeping Programs III-10
III.4 Modified Detention Basin and Retention Basin Design Criteria to Maximize Their Pollutant Removal Effectiveness III-15

CHAPTER IV

IV.1 Public Works Expenditures by Local Units of Government in Southeastern Wisconsin by County: 1978 .... IV-2
IV.2 Distribution of Public Works Expenditures by Local Units of Government in Southeastern Wisconsin: 1978 .... IV-4
IV.3 Street and Alley Sweeping Costs for the City of Milwaukee, Wisconsin: 1976-1980 .... IV-6
IV.4 Distribution of Cost and Unit Cost for Street Sweeping Programs IV-7

CHAPTER V

V.1 Existing Land Use in the Noyes Creek Watershed: 1980 ...... V-7
V.2 Selected Physical Characteristics of the Noyes Creek Watershed: 1980 .... V-8
V.3 Seasonal Averages and Ranges of Streamflow and Concentration of Selected Water Quality Parameters in the Noyes Creek: 1976-1977 .... V-10
V.4 Description of Nonpoint Source Control Alternatives for the Noyes Creek Watershed V-12
V.5 Pollutant Loading Reductions Anticipated Under Alternative Nonpoint Source Control Measures for the Noyes Creek Watershed V-14
V.6 Economic Analysis of Alternative Nonpoint Source Control Measures for the Noyes Creek Watershed V-15
V.7 Cost Effectiveness Analysis of Alternative Nonpoint Source Control Measures for the Noyes Creek Watershed V-17
V.8 Existing Land Use in the Upper Root River Watershed: 1980.. V-21
V.9 Selected Physical Characteristics of the Upper Root River Watershed: 1980 .... V-22
V.10 Water Quality Conditions in the Upper Root River at W. Grange Avenue, Village of Greendale: 1968-1975 .... V-23
V.11 Description of Nonpoint Source Control Alternatives for the Upper Root River Watershed V-25

Number Page

V.12 Pollutant Loading Reductions Anticipated Under Alternative Nonpoint Source Control Measures in the Upper Root River Watershed V-28
V.13 Economic Analysis of Alternative Nonpoint Source Control Measures for the Upper Root River Watershed V-29
V.14 Cost Effectiveness Analysis of Alternative Nonpoint Source Control Measures for the Upper Root River Watershed V-31
V.15 Existing Land Use in the Lincoln Creek Watershed: 1980 .... V-35
V.16 Selected Physical Characteristics of the Lincoln Creek Watershed: 1980 .... V-36
V.17 Water Quality Conditions in Lincoln Creek at Cameron Avenue, City of Milwaukee: November 1976 - April 1977 .... V-37
V.18 Description of Nonpoint Source Control Alternatives for Lincoln Creek Watershed V-39
V.19 Pollutant Loading Reductions Anticipated Under Alternative Nonpoint Source Control Measures in the Lincoln Creek Watershed V-42
V.20 Economic Analysis of Alternative Nonpoint Source Control Measures for Lincoln Creek Watershed V-43
V.21 Cost Effectiveness Analysis of Alternative Nonpoint Source Control Measures for the Lincoln Creek Watershed V-45

CHAPTER I

INTRODUCTION

INTRODUCTION

Historically, urban stormwater runoff has been viewed as a drainage problem. Stormwater drainage is one of the most important and costly requirements of sound urban development, and is essential to the provision of an attractive and efficient, as well as to a safe and healthful environment for urban life. Inadequate drainage can be costly, can depreciate and destroy property, and can create a serious hazard to public health and safety.

Public officials are increasingly recognizing the adverse ecological and environmental impacts of improperly managed urban stormwater runoff, including the pollution of surface waters and impacts on fish and aquatic life. The regional water quality management--or Section 208--plans for many areas, including southeastern Wisconsin, concluded that urban stormwater runoff was a significant cause of water quality degradation. To achieve water use objectives and supporting water quality standards, the regional water quality management plan for southeastern Wisconsin recommended that certain low cost, "proper" land management practices be implemented in all urban areas of the Southeastern Wisconsin Region (SEWRPC, 1979), with the exception of the combined sewer service area. For select urban areas--about 16 percent of the planned year 2000 urban area of the Region--experiencing relatively severe water quality problems which were in part attributed to urban runoff, the plan recommended the implementation of additional, more costly urban land management practices.

However, because of the complexity of urban areas and the limited amount of data available to assess the quality and effects of urban runoff and the effectiveness of the control practices, it was concluded that additional information was needed prior to the actual selection and implementation of urban nonpoint source control programs. Additional information was needed concerning the pollutant washoff and transport mechanisms, specific sources of pollutants, costs and effectiveness of specific urban nonpoint source control measures, and the water quality benefits resulting from the control measures.

This three-volume report of the Nationwide Urban Runoff Program (NURP) study in Milwaukee County conducted jointly by the Wisconsin Department of Natural Resources, the U.S. Geological Survey, and the Southeastern Wisconsin Regional Planning Commission, characterizes urban runoff and evaluates street sweeping as an urban nonpoint source control measure. This volume of the report, however, also evaluates stormwater detention and retention basins and catch basin cleaning as potential nonpoint source control measures. Detention and retention basins and catch basin cleaning are evaluated to provide comparisons to street sweeping concerning feasibility, costs, and pollutant removal effectiveness. Other NURP studies have also assessed the costs and pollutant removal effectiveness of detention and retention basins and catch basin cleaning; and some of these study results are potentially applicable and useful to municipalities in Wisconsin.

PURPOSE AND SCOPE

Volume One of this report, Urban Stormwater Characteristics, Sources, and Pollutant Management By Street Sweeping, characterized urban stormwater runoff volumes, pollutant concentrations and loadings, and water quality impacts on receiving waters. Volume One also identified and quantified sources of urban stormwater contaminants, and evaluated the effectiveness of various frequencies of street sweeping in removing pollutant loadings from the street surface and from urban stormwater runoff. Volume One was based on the data collected in the Milwaukee County NURP study.

The purpose of this volume is to evaluate the costs of street sweeping, as well as of detention and retention basins and catch basin cleaning; and to evaluate the feasibility and cost effectiveness of implementing these measures in urban areas generally and in select areas of southeastern Wisconsin specifically. This volume is thus intended to demonstrate the applicability of these measures to certain urban areas, and to quantify the costs and pollutant removal rates which may be expected to be associated with these measures. It is important to note that this volume does not present plans or recommendations for urban nonpoint source control for select areas; the volume only sets forth estimates of the costs and pollutant removals anticipated if the measures entailed were implemented in these select areas.

Chapter II summarizes this volume and presents conclusions concerning the application of the study data and results to other urban areas in the development of urban nonpoint source control programs. Costs and pollutant removal effectiveness are summarized for the various urban nonpoint source control measures evaluated.

Chapter III of this volume describes each nonpoint source control measure and discusses the objectives, applicability, size or extent, problems, pollutant abatement effectiveness, and administrative considerations attendant to each measure. This chapter is intended to provide information which can be used to determine whether a measure is appropriate for a given area, what approximate size or extent of the measure would be required to provide water quality benefits, what problems would likely be encountered, and how the nonpoint source control measure could be properly designed and managed.

Chapter IV of this volume presents the costs of street sweeping and of detention and retention basins and catch basin cleaning. Cost estimates were obtained from various NURP studies, from literature sources, and from data collected by the Southeastern Wisconsin Regional Planning Commission. Wherever possible, costs are allocated to the various aspects of construction and operation and maintenance of the measures, and unit costs are presented which may be used to estimate the costs of these measures in other urban areas.

Chapter V of this volume evaluates the applicability, costs, and pollutant removal rates which may be expected to be associated with application of improved street sweeping, modified detention and retention basins, and catch basin cleaning in three watersheds in southeastern Wisconsin. Those three watersheds are the Noyes Creek watershed, which is primarily in medium density residential and related land uses; the Lincoln Creek watershed, which is primarily in high density residential and related land uses; and the Upper Root River watershed, which is developing primarily in low and medium density residential and related land uses.

Chapter VI of this volume describes the public participation and informational efforts conducted under the study and describes a public education program which could be used to assist in the implementation of urban nonpoint source control measures.

The information contained in this volume, together with the information contained in Volume One, should contribute materially to the better understanding of urban nonpoint source problems and processes, and of certain practices which can be used to help abate these problems. Although the severity of nonpoint source pollution problems and the effectiveness of pollution control measures are highly site specific, the results presented herein provide a sound basis for decision-making related to certain urban land management practices.

CHAPTER II

SUMMARY AND CONCLUSIONS

INTRODUCTION

The development of an urban nonpoint source control program requires that the pollutants causing water quality problems be identified, that the sources of those pollutants be identified, and that appropriate nonpoint source control measures be selected to achieve the desired level of nonpoint source control in a cost effective and practical manner. This volume provides a basis for selecting appropriate nonpoint source control measures for urban areas, and describes a means of estimating, at a systems planning level, the cost and pollutant removal effectiveness of these urban nonpoint source control measures.

This volume of the Nationwide Urban Runoff Program (NURP) study report in Milwaukee County evaluates street sweeping, stormwater storage basins, and catch basin cleaning as potential urban nonpoint source pollution abatement measures. The applicability of these measures to certain urban areas is demonstrated, and associated costs and pollutant removal levels achieved are quantified.

STREET SWEEPING

Street sweeping can be performed using mechanical sweepers, vacuum sweepers, regenerative air system sweepers, or by manual sweeping. Existing street sweeping programs are primarily designed to improve aesthetics and minimize costs rather than to provide the maximum water quality benefits. In general, street sweeping is applicable to essentially all urban areas served by streets with an urban cross section; that is, by streets with curbs and gutters. The number of street sweepers utilized, as well as the required operator and maintenance personnel, are primarily dependent upon the total number of curb miles to be swept and upon the frequency of sweeping. Generally, from 25 to 45 miles can be swept during an 8-hour shift.

Effective street sweeping can be hindered by vehicles parked on streets which prevent direct access to the curb, poor street surface conditions, traffic congestion, excessive litter and construction site erosion, and snow and ice conditions on the street. The effectiveness of street sweeping can often be improved by increasing the efficiency of the sweepers to remove pollutant loads from the street surface, by optimizing the frequency and timing of sweeping, and by reducing the accumulation of pollutant loads on the street surface by such measures as litter control ordinances and improved leaf collection practices.

The cost of street sweeping typically represents about 1 percent of the total public works budget. Street sweeping is a relatively labor-intensive public works operation, with about 50 percent of the total cost being required for wages and fringe benefits. On the average, street sweeping costs about $16 per curb mile swept, or about $26 per cubic yard of solids collected.

The pollutant removal effectiveness of street sweeping is relatively modest. Existing street sweeping programs may achieve up to a 10 percent reduction in pollutant loadings, compared to areas that are not swept at all. Two levels of improved street sweeping were evaluated in this volume. The first level of improved street sweeping evaluated consisted of an increased frequency of sweeping only during March and during October, when street surface loadings would be expected to be at their highest levels. For three study watersheds evaluated, this first level of improved street sweeping can be expected to provide up to a 17 percent reduction in pollutant loadings to surface waters, compared to the existing loadings. The percent reduction achieved is highly dependent on the specific pollutant, with the maximum reductions being 9 percent for total solids, 12 percent for volatile suspended solids, less than 1 percent for nitrogen, 12 percent for phosphorus, and 17 percent for lead. Implementing this first level of improved street sweeping would increase existing street sweeping costs in the three study watersheds by an average of about 50 percent.

The second level of improved street sweeping evaluated consisted of an increased frequency of street sweeping during the entire sweeping season, from March through November. For the two study watersheds evaluated for this alternative, the percent reductions in existing pollutant loads achieved were only slightly higher than with the first level of improved street sweeping, ranging up to 18 percent. The maximum reductions which can be expected to be achieved by this second level of improved street sweeping are 13 percent for total solids, 14 percent for volatile suspended solids, less than 1 percent for nitrogen, 14 percent for phosphorus, and 18 percent for lead. Implementing this second level of improved street sweeping would increase existing street sweeping costs in the two study watersheds by nearly 150 percent.

STORMWATER STORAGE BASINS

Stormwater storage facilities may consist of retention facilities, which retain a permanent pool of water between storm events, or of detention facilities, which drain completely and thus are dry between storm events. This volume evaluates the cost and pollutant removal effectiveness of surface retention basins and of detention basins which have been modified to drain slowly, thereby operating essentially as retention basins during, and for a period of time, following a storm event. Other NURP studies have indicated that retention basins and modified detention basins can achieve a relatively high level of pollutant removal.

Most retention basins and detention basins are constructed primarily for flood control purposes and to reduce the cost of downstream drainage facilities. Other benefits which may be provided include pollutant removal, aesthetic enhancement, and a reduction in downstream streambank erosion. Such basins are most readily applicable to urban areas which have existing open lands located adjacent to a small intermittent stream or drainage ditch.

Limitations to the effective use of retention or modified detention basins in some areas may be due to a lack of suitable open land, interference with other facilities such as streets and buildings, poor maintenance, improper flood routing through the basins, and poor public acceptance of the basins. Many of these potential problems, though, can be minimized or eliminated by the use of proper hydraulic analytical techniques and design procedures, and by a carefully developed long-term maintenance program.

The pollutant removal effectiveness of retention basins and modified detention basins can be estimated by the application of a series of curves which indicate the level of pollutant removal as a function of the ratio of the basin area to the tributary drainage area. The maximum levels of pollutant removal which can be achieved by the basins, as indicated by the curves, are more than 95 percent for total solids, more than 85 percent for lead, about 75 percent for phosphorus, and about 60 percent for nitrogen, organic matter, and certain metals.

Local agencies and private land developers responsible for modified detention basins and retention basins may encounter costs for administration, planning, land acquisition, construction, and operation and maintenance. A capital cost curve is presented in this volume to estimate capital costs as a function of the design storage capacity of the basins in cubic feet. The capital cost curve, presented in Figure IV-1, applies to basins with storage capacities ranging from 1,000 to 1,000,000 cubic feet. To estimate the annual operation and maintenance costs, it was assumed that such costs would approximate 5 percent of the capital cost.

When evaluated as an alternative nonpoint source control measure for three study watersheds, it was found that retention basins or modified detention basins could be expected to remove at least 50 percent and as much as 93 percent of the pollutant loads entering the basins. However, because in some instances only a small portion of a watershed would drain to a retention basin or modified detention basin, as little as 5 percent of the total pollutant loadings from a watershed could be removed under this alternative. On a per-acre-treated basis, the cost analyses indicated that the use of retention basins or modified detention basins is substantially more expensive than the cost of improved street sweeping programs, although the corresponding level of pollutant removal is also much higher for the basins.

CATCH BASIN CLEANING

Catch basin cleaning, either manually or by using specially designed bucket loaders, vacuum eductors, or vacuum attachments to street sweepers, removes sediment and debris from the storm sewer system before it reaches receiving waters. Most municipalities currently clean their catch basins at frequencies ranging from once every three years to twice per year. Catch basins are primarily cleaned to prevent the clogging of storm sewers and to prevent the discharge of foul odors caused by the decomposition of the accumulated debris. Pollutant removal and water quality protection are thus secondary benefits of catch basin cleaning.

Most urban areas served by storm sewers contain from 12 to 18 catch basins per curb mile of street. Between 10 and 20 catch basins can usually be cleaned per day by a cleaning crew. Catch basin cleaning costs generally range from $6 to $8 per basin cleaned. Catch basin cleaning can be hindered in some areas by traffic and parking conditions, and snow and ice generally precludes cleaning operations.

Although catch basins are relatively effective in trapping large particles, the rate at which catch basins fill with debris, as well as the total amount of material which can be removed by different frequencies of cleaning, are highly variable and cannot be accurately predicted using the NURP study data.

Thus, it is not possible, based on the data currently available, to quantify the pollutant removal effectiveness of catch basin cleaning. However, such cleaning does provide benefits including the removal of pollutant loads, the reduction of high pollutant concentrations during the "first flush" of a storm event, and the prevention of clogging of the storm sewer system.

EVALUATION OF ALTERNATIVES

The study watershed evaluations indicate that the cost and the pollutant removal effectiveness of urban nonpoint source control measures is highly site specific, varying substantially with the type and intensity of urban land use. Table II-1 sets forth a comparison of the pollutant loading reductions, cost, and cost effectiveness associated with improved street sweeping, stormwater storage, and combination--improved street sweeping plus stormwater storage--alternatives for the three study watersheds. To provide a basis for the comparison, unit costs are presented per acre of watershed area, and the pollutant loading reductions and cost effectiveness data are presented only for total solids.

With respect to improved street sweeping, the table indicates that less than a 10 percent reduction in solids loadings can generally be achieved by this alternative. The percent of solids removed increases as the density of the urban land use increases; the high-urban-density Lincoln Creek watershed has the highest removal level at 9.4 percent. For the Upper Root River watershed, improved street sweeping would remove only a negligible amount of solids because of the low to moderate density urban development, and because most of the streets in the watershed are not swept at all. The annual unit cost figures indicate that the cost of an improved street sweeping program for high density development--$4.29 per acre for the Lincoln Creek watershed--is about 10 percent higher than the cost of an improved sweeping program for medium density development--$3.89 per acre for the Noyes Creek watershed. The unit cost for the Upper Root River watershed is less than $1.00 per acre because only a small portion of the watershed would be swept. Improved street sweeping is most cost effective for the high density Lincoln Creek watershed and least cost effective for the low to moderate density Upper Root River watershed.

The effectiveness and cost of stormwater storage is even more variable than is improved street sweeping. The solids removal level for Noyes Creek was very high--93 percent--because the watershed is small enough so that the entire watershed can drain to one retention or modified detention basin and because a suitable site was available for the basin. However, where suitable open land sites on a surface water drainageway are limited or scarce, less than 25 percent removal rates for the entire watershed may be expected. It should be noted that for all three study watersheds, the pollutant removal rates under the stormwater storage alternative were higher than under the improved street sweeping alternative. The unit costs increase as the percent of the watershed which would drain to the storage basins increase. For example, the Noyes Creek watershed, where 100 percent of the watershed would drain to a basin, has a unit cost of $14.09 per acre, whereas the Lincoln Creek watershed, where only 14 percent of the watershed would drain to a storage basin, has a unit cost of only $2.87 per acre of watershed. For all three study watersheds stormwater storage, at a cost effectiveness level ranging from $0.15 to $0.26 per pound of solids removed, was significantly more cost effective than improved street sweeping.

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Table II-1

COMPARISON OF URBAN NONPOINT SOURCE CONTROL ALTERNATIVES FOR THE STUDY WATERSHEDS

	Improved Street Sweeping Program I[a]			Stormwater Storage[b]			Combination Improved Street Sweeping Program and Stormwater Storage		
Watershed	Total Solids Loading Reduction (Percent)	Unit Cost (Equivalent Annual Cost Per Acre)	Cost Effectiveness (Equivalent Annual Cost Per Pound of Solids Removed)	Total Solids Loading Reduction (Percent)	Unit Cost (Equivalent Annual Cost Per Acre)	Cost Effectiveness (Equivalent Annual Cost Per Pound of Solids Removed)	Total Solids Loading Reduction (Percent)	Unit Cost (Equivalent Annual Cost Per Acre)	Cost Effectiveness (Equivalent Annual Cost Per Pound of Solids Removed)
Noyes Creek	6.8	3.89	0.56	93.0	14.09	0.15	93.5	17.98	0.19
Upper Root River	0.7	0.83	0.68	24.5	8.06	0.19	25.0	8.89	0.20
Lincoln Creek	9.4	4.29	0.39	9.5	2.87	0.26	18.0	7.16	0.34
Mean	5.6	3.00	0.54	42.3	8.34	0.20	45.5	11.34	0.24

[a] Only the Improved Street Sweeping Program I alternatives are presented because the watershed evaluations indicated that the Improved Street Sweeping Program II alternatives were substantially more costly than the Program I alternatives but provided minimal additional pollutant removal.

[b] Includes the Stormwater Storage II alternative for the Noyes Creek watershed because that alternative was significantly more cost effective than the Stormwater Storage I alternative.

Source: SEWRPC

The combination alternatives provide the highest levels of pollutant removal However, for the Noyes Creek and Upper Root River watersheds, the combination alternatives provide only a negligible improvement in pollutant loadings over the stormwater storage alternatives. Only for the Lincoln Creek watershed does the combination alternative provide a significant improvement over the stormwater storage alternative. Although a very high--93.5 percent--level of total solids loading reduction can be achieved for the Noyes Creek watershed, the associated unit cost of $17.98 per acre is more than twice as high as the unit cost for either the Upper Root River or Lincoln Creek watersheds. For all three study watersheds, the combination alternative is more cost effective than the improved street sweeping alternative but less cost effective than the stormwater storage alternative.

CONCLUSIONS

The analysis of selected urban nonpoint source control measures has demonstrated that such measures can be used to achieve a significant level of pollutant loading reduction. However, because of variable costs and pollutant removal levels, care must be taken to select the appropriate control measure which achieves the desired level of pollution control in a cost effective manner. The pollutant removal effectiveness and cost of urban nonpoint source control measures vary between sites, and the planning and design of control measures requires an individualized evaluation of the nonpoint pollution sources, site characteristics, and applicable control measures. Specific conclusions of this volume are as follows:

1. An improved street sweeping program may be appropriate for some medium and high density urban areas. However, the level of pollution control achieved is likely to be relatively modest--up to a 10 percent reduction in existing solids loadings and up to an 18 percent reduction in existing lead loadings. It is important to note that street sweeping will continue to be conducted for aesthetic purposes, and that increased sweeping in spring and in fall is most effective.

2. The cost of the improved street sweeping programs tends to be rather high--requiring at least a 25 percent and as much as a 150 percent increase in the existing street sweeping costs--given the modest level of pollution control achieved. Hence, improved street sweeping tends to be less cost-effective than other nonpoint source controls evaluated for most urban areas.

3. More effective street sweeping techniques, as well as methods of reducing the cost of improved street sweeping programs should be investigated and developed.

4. High levels of pollutant removal--up to more than 90 percent or more--can be achieved by properly designed and operated retention basins and modified detention basins. Because of this high level of removal, such basins need not serve an entire urban area in order to achieve a significant reduction in nonpoint source pollutant loadings.

5. Although costly, stormwater retention basins and modified detention basins can serve multiple-purposes and provide non-water quality benefits. Properly designed, constructed, and maintained basins can serve

their intended junctions and be an attractive addition to the local setting throughout their useful life.

6. It was not possible, based on the data currently available, to quantify the effectiveness of catch basin cleaning. However, the information available indicates that where such basins are present, they should be cleaned at least once or twice each year.

7. The cost effectiveness analyses set forth in this volume indicate that the most cost effective nonpoint source control alternatives for the study watersheds would have an average cost of $0.20 per pound of solids removed, $3.45 per pound of volatile suspended solids removed, $12.17 per pound of nitrogen removed, $144 per pound of phosphorus removed, and $387 per pound of lead removed.

8. The analyses have demonstrated that there are reliable and reasonably accurate analytical techniques available which may be used to evaluate, on a systems planning level, alternative nonpoint source control measures for urban areas. The Wisconsin Urban Runoff Model (WURM) and Street Load and Washoff Model (SLAW) can be utilized to estimate pollutant loadings from urban areas and the water quality impacts of street sweeping. Pollutant removal curves are presented to evaluate the effectiveness of retention basins and modified detention basins. Relatively simple cost functions are set forth to analyze the economic aspects of the various nonpoint source control measures. The actual design of urban nonpoint source control measures, however, requires a site specific analysis. The above analytical techniques should be modified to reflect those site specific conditions and these techniques should be supplemented by detailed engineering design procedures.

This volume presents information concerning urban nonpoint source pollution control which should be useful in evaluating and selecting alternative nonpoint source control measures for specific urban areas in Wisconsin. The information should be of assistance to state and federal agencies, local planners and engineers, and individual communities who wish to develop urban nonpoint source control strategies.

CHAPTER III

FEASIBILITY OF URBAN NONPOINT SOURCE CONTROL MEASURES

INTRODUCTION

The successful implementation and public acceptance of an urban nonpoint source control program requires that the proposed control measures be directly related to water quality improvement, and that the costs of the control measures be commensurate with the water quality and other benefits provided, and reasonable with respect to related public works expenditures. There generally are three phases in the development of an urban nonpoint source control program, as discussed below. The objectives, applicability, size or extent of operation, design and administrative considerations, and the problems encountered in the application of improved street sweeping programs, and in the development and maintenance of detention and retention basins are also addressed.

NURP studies in Milwaukee and in other urban areas have evaluated the major pollutants associated with urban runoff, identified the sources of those pollutants, and evaluated the cost and pollutant removal effectiveness of improved street sweeping, detention and retention basins, catch basin cleaning, and several other control measures. The results of the Milwaukee and other NURP studies, together with information from the literature, were used to evaluate the feasibility of implementing these practices in urban areas.

DEVELOPMENT OF AN URBAN NONPOINT SOURCE CONTROL PROGRAM

The first phase in developing an urban nonpoint source control program is to identify the pollutants causing water quality problems in the receiving waters. Water quality conditions can be evaluated by monitoring the chemical constituents of the receiving water, by the use of water quality simulation models, and by assessing the biological conditions in the receiving water. The application of water quality standards can be used to relate measured or simulated water quality data to specific beneficial uses of the water. Surface waters in urban environments often have relatively high concentrations of nutrients, sediment, metals, organic substances, and micro-organisms.

The second phase in developing an urban nonpoint source control program is to identify and quantify the sources of those pollutants causing water quality problems. Water quality monitoring of appropriate source areas and water quality simulation models are again useful in determining the sources of pollutants. Field surveys and observations are another important means of identifying pollution sources. Water pollution sources can generally be categorized as point sources, rural nonpoint sources, and urban nonpoint sources. Urban nonpoint sources include storm runoff from rooftops, street surfaces, and parking lots; litter; pet waste; leaves, grass clippings, and other vegetative debris; commercial and industrial site storm runoff; construction site and other soil erosion; and street deicing chemicals.

The third phase in developing an urban nonpoint source control program is to evaluate and select those nonpoint source control measures which can achieve the desired level of pollutant removal in a cost-effective manner, and which are applicable to, and feasible in, the subject area. Potential urban nonpoint source control measures include improved street sweeping, stormwater storage, catch basin cleaning, litter and pet waste control, construction site erosion control, commercial and industrial site runoff control, leaf collection, reduced deicing chemical use, and public education programs.

STREET SWEEPING

Description

Motorized street sweepers are designed to dislodge debris and dirt from the street surface, transport it onto a moving conveyor, and deposit it into a storage hopper. The most common type of street sweeper is a mechanical sweeper, which uses a rotating gutter broom to transport particles from the gutter area into the path of a large cylindrical broom which rotates to carry the material onto a conveyor belt. Water is sprayed on the collected material to control resuspension of the fine particles. A 1973 American Public Works Association (APWA) survey (1979) of municipal officials indicated that, nationwide, about 66 percent of all streets cleaned are cleaned with mechanical sweepers. Mechanical street sweepers were used in the Milwaukee NURP study. A second type of street sweeper is a vacuum street sweeper, which uses gutter and main pickup brooms for dislodging and transporting street debris and dirt into the path of a vacuum intake, which places the debris into the hopper. The collected dirt is sprayed with water and settles out in the hopper. A third type of street sweeper is regenerative air system sweeper. These sweepers "blast" the dirt and debris from the street surface into the hopper, and the air is then vented through a dust separation system. The APWA survey indicated that, nationwide, about 25 percent of the streets cleaned were cleaned with vacuum or regenerative air sweepers. The remaining 9 percent of streets were cleaned with flushers or by a combination of street cleaners. The material collected is taken to a disposal site such as a sanitary landfill. In southeastern Wisconsin, most street sweeper loadings are disposed of at landfills (SEWRPC, 1977).

Objectives

Existing street sweeping programs are primarily designed to improve aesthetics and minimize costs rather than to remove the maximum amount of potential water pollutants. A 1975 survey of municipal officials by the APWA indicated that the primary street sweeping goals of 43 percent of the respondents were to provide a particular service level in a cost-effective manner and thereby to satisfy the public (APWA, 1978). The primary goals of 41 percent of the respondents were to provide streets which have a neat appearance, are litter free, and which have reduced amounts of visual dust and dirt. Only 7 percent of those surveyed responded that the primary goals of their street cleaning programs were to reduce water pollution, protect the storm water system, or for sanitation. To utilize street sweeping to its maximum potential as an urban nonpoint source control measure, pollutant removal effectiveness will need to receive greater emphasis as an objective of street sweeping programs by municipal public works directors and elected officials.

Applicability

With respect to pollutant removal, street sweeping is technically applicable to essentially all urban areas served by streets with an urban cross section, that is, by streets with curbs and gutters. In areas served by streets with a suburban or rural cross section, that is, with road ditches in place of curbs and gutters, street sweeping may be used for aesthetic and litter control purposes, but the pollutant removal benefits of the sweeping are likely to be limited because the street debris and dirt would not be concentrated in a gutter area for effective pickup. In street sections with curb and gutter, no parked cars, smooth street surfaces, and moderate to heavy traffic volumes, from 70 to 80 percent of the street debris lies within six inches of the curb, and up to 90 percent lies within 12 inches (Sartor and Boyd, 1972).

One of the most important determinants of the existence and character of a municipal street sweeping program is economics. Municipalities who develop street sweeping programs require a sufficient revenue base to purchase a street sweeper at a cost--if new--ranging from about $45,000 to $100,000, depending upon the type and the amount of auxiliary attachments, to employ operators and maintenance technicians for the sweeper, to administer the operation, and to manage the daily scheduling and routing of the sweepers, and disposal of the collected material. In addition to regular street sweeping, many municipalities utilize the sweepers for leaf collection, catch basin cleaning, construction site cleanup, and parking lot cleaning. Of seven cities and three villages within the Root River watershed in southeastern Wisconsin, three of the cities and two of the villages had street cleaning programs (SEWRPC, 1980). A 1977 survey of street cleaning practices of 14 cities, three villages, and three towns in the Southeastern Wisconsin Region indicated that 13, or 93 percent of the cities; two, or 67 percent of the villages; and none of the towns had street sweeping programs (SEWRPC, 1977). In addition, the State of Wisconsin conducts sweeping operations on some state highways and some county highways are swept by county highway departments.

Size of Operation

The number of street sweepers utilized in a street sweeping program, as well as the required operator and maintenance personnel, are primarily dependent upon the total number of curb-miles to be swept and upon the frequency of sweeping. Table III.1 sets forth results of nationwide surveys of various-sized municipalities indicating the average number of street sweepers, the average number of curb-miles in the municipality per sweeper, and the average length of a street sweeping route for an 8-hour shift. A 1975 APWA survey indicated that commercial and industrial areas are usually swept an average of one to three times per week, while residential areas are usually swept about once or twice per month (APWA, 1978). Table III.1 indicates that the municipalities surveyed averaged one street sweeper for every 60 to 130 miles of curb within the municipality. Average street sweeping routes for an 8-hour shift ranged from 25 to 45 miles. During an average shift, about 15 cubic yards of material are collected (Pitt, 1979). The most common street sweeper hopper sizes are three and four cubic yards; therefore, about four or five loads are usually collected during each shift.

A study on the use of street sweepers by the City of Milwaukee indicated that maintenance and repair costs for street sweepers increase substantially after the sweeper's eighth year of service (Bureau of Budget and Management Analysis, City of Milwaukee, 1976). The sweepers in Milwaukee were being replaced after an average of 14 years of service. The study recommended that the city replace sweepers after their eighth year of service. The study also found that hand sweeping costs were approximately four times as much as motorized sweeping. The study therefore recommended that hand sweeping of streets and alleys by regular city employees be phased out.

Table III.1

NATIONWIDE SURVEY OF AVERAGE MUNICIPALITY AREAS, CURB LENGTH, AND STREET SWEEPER OPERATIONS

Municipality Population Range	Area (Miles^2)[b]	Total Street Length Curb Miles[a,b]	Number of Street Sweepers[d]	Number of Curb Miles per Street Sweeper[a,c]	Length of Street Sweeper Routes (Curb Miles Swept/Shift)[b]
7,000-25,000	10	170	2-3	60	30
26,000-50,000	15	260	2-3	110	45
51,000-100,000	35	440	4	100	40
101,000-250,000	50	880	7	130	30
251,000-500,000	110	1,660	17	100	25

[a] Curb-miles estimated by multiplying the number of street-miles by two.

[b] 1973 APWA Survey cited in American Public Works Association, Street Cleaning Practice, 1978.

[c] C. W. Laird and J. Scott, "How Street Sweepers Perform Today", American City, March 1971.

[d] Derived from APWA (1979) and Laird and Scott (1971) data.

Source: SEWRPC

Problems

The effectiveness of street sweeping in a municipality depends upon the physical characteristics and the parking, traffic, and litter conditions in the municipality, as well as upon the management and operation of the street sweeping program. Table III.2 sets forth the results of a 1975 survey of 152 cities by the American Public Works Association of the factors which most commonly interfered with effective street sweeping (APWA, 1978).

Vehicles parked at curbs constitute the major obstacle to effective street sweeping. Figure III.1 illustrates the relationship between the percent of the curb without parked vehicles and the percent of the street curb which can be swept. For example, if parked vehicles are located along 50 percent of the curb-length, only 15 percent of the street could be swept because of the additional length required for manuvering around the parked vehicles. Since about 90 percent of all street dirt and debris lies within one foot of the curb, parked vehicles have a very important impact on the amount of pollutants which can be removed by sweeping. In addition, parked vehicles reduce the accumulation of particulates near the curb, resulting in higher loadings toward the middle of the street, which are more difficult to remove by sweeping.

Street surfaces that are irregular, or that have many cracks, joints, and potholes are more difficult to sweep effectively than are those surfaces which are smooth and well-maintained. Rough surfaced streets have a more even distribution of debris across the street surface and may have from two to six times more debris on the street than do smooth surface streets (Pitt, 1979). It should be noted that although rough surfaced streets will not be as clean following sweeping as will smooth surfaced streets, a large amount of material can be swept off of rough surface streets because of the high initial loadings present. Streets without curbs and gutters, or with poorly designed curbs and gutters which do not accumulate debris, can be expected to have lower pollutant removal rates by street sweeping.

Congested traffic will often make street sweeping impractical because of the inability of the sweeper operator to manuver the sweeper consistently along the curb and because of the potential for causing accidents. Streets subject to high traffic volumes may need to be swept during the evening or off-peak periods when traffic is at a minimum.

Unpaved and poorly vegetated areas, such as construction sites, and unpaved streets, parking lots, and driveways, subject to erosion may generate large amounts of sediment. These pervious areas cannot be cleaned by street sweepers. Erosion control measures are needed to reduce pollutant loadings from these pervious areas.

Climate and weather, particularly snow and ice, restrict street sweeping in Wisconsin. Within southeastern Wisconsin, street sweeping is generally conducted from about the beginning of April through the end of November. However, the sweeping season may extend through December and even into January if heavy snowfalls do not occur. The City of Milwaukee reported that, in 1975, the street sweeping program began on April 1 and ended on November 21 (Bureau of Budget and Management Analysis, City of Milwaukee, 1976). Over that approximately 8-month period, street sweeping was interrupted for only five days by climate--three days due to snow and two days due to intense rainfall.

Table III.2

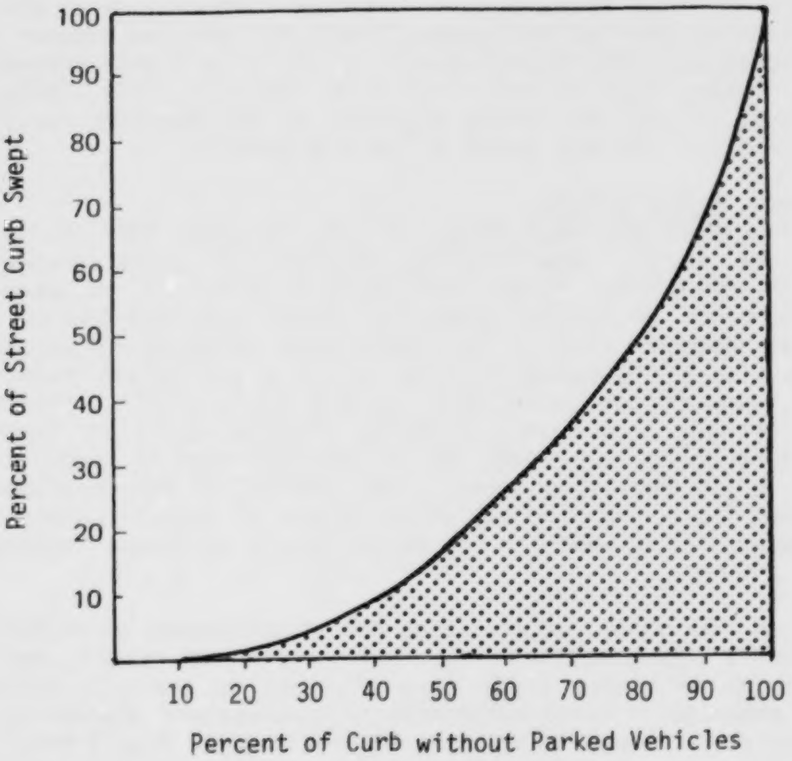
INTERFERENCES TO EFFECTIVE STREET SWEEPING

Rank	Interference	Average Importance
1.	Parked Vehicles on Streets	High
2.	Street Surface Conditions	Medium
3.	Traffic Congestion	Medium
4.	Construction Projects	Medium
5.	Lack of Litter-Control Program	Medium
6.	Climate	Medium
7.	Curb Conditions	Low
8.	Absence of Curbs	Low
9.	Curb Design	Low
10.	Maturity of Vegetation	Low
11.	Absence of Permanent Posting	Low
12.	Unpaved Driveways	Low
13.	Demolition Work	Low
14.	Lack of Vegetation	Low
15.	Unpaved Streets	Low
16.	Unpaved Parking Lots	Low

Source: American Public Works Association Survey, 1975.

Figure III-1

EFFECT OF VEHICLE PARKING ON STREET SWEEPING



Source: Levis, Alexander F., and Destefano, Louis T., A Model for the Effect of Illegally Parked Cars on Street Cleaning, Journal of Environmental Systems, Vol. 2, June 1972.

Street sweeping performance is also very sensitive to operator skill and to the level of sweeper maintenance provided. Inexperienced or poorly skilled operators may be unable to properly adjust the sweepers to optimize pollutant removal, may be unable to sweep at the optimal vehicle speed and to effectively manuver around parked vehicles, and may improperly dispose of the collected materials. Interim disposal and storage of the collected debris is one of the major complaints concerning street sweeping. Pitt (1979) reported that interim storage of collected material on streets in various cities averaged 6 hours and ranged from five minutes to three days. This stored material on the streets is subject to tracking and resuspension prior to final transport to a landfill or other disposal site. Pollutant removal rates are dependent upon the rotating rate of the sweeper brush and upon the sweeper vehicle speed. Higher brush rotating speeds generally result in higher removal rates and the optimal sweeper speed is about four miles per hour (APWA, 1978). Only 43, or 28 percent, of the 152 cities surveyed by the American Public Works Association in 1975 had a formal operator training program.

Pollution Abatement Effectiveness

The results of the Milwaukee NURP study, as well as other NURP studies, have indicated that the overall water quality benefits of street sweeping are modest. Although variability in the data makes it difficult to quantify the water quality benefits of street sweeping, Street Load and Washoff (SLAW) modeling analyses indicate that it is likely that existing street sweeping programs in the City of Milwaukee achieve up to a 10 percent reduction in solids loadings, compared to areas that are not swept at all. Furthermore, the data indicate that many street sweeping programs could be improved in order to achieve up to an additional 10 percent reduction in nonpoint source solids loadings to the receiving waters. The results of the Milwaukee study concerning the factors influencing the effectiveness of street sweeping can be utilized to suggest ways to maximize the reductions in pollutant loadings from street sweeping programs.

To isolate some of the variables affecting the effectiveness of street sweeping and to quantify improvements in the quality of urban runoff, two models developed under the Milwaukee study were utilized to evaluate alternative street sweeping programs in three watersheds in southeastern Wisconsin, as set forth in the Chapter V. These models--the Wisconsin Urban Runoff Model (WURM) and the Street Load and Washoff (SLAW) model--are discussed in detail in Volume Three, Study Site Characteristics, Experimental Methods, and Quality Assurance Program for the Milwaukee Urban Runoff Program. The WURM model was used to estimate pollutant loadings to receiving waters under existing conditions. The SLAW model results, as set forth in Volume One, were used to determine the pollutant loading reductions expected under various improved street sweeping alternatives.

Administration and Management

Most municipal street sweeping programs are administered by the public works department, whose activities are carried out to improve the quality of the urban environment. A survey by the American Public Works Association indicated that snow removal, street maintenance, and street cleaning were carried out by more than 96 percent of the municipal public works departments surveyed. Most municipalities purchase and maintain their own street sweepers, although some lease the equipment or contract for services from private firms. A comprehensive discussion of the management, operation, and administration of street sweeping programs is set forth in Street Cleaning Practice, published by the American Public Works Association in 1978.

The pollutant removal effectiveness of many, if not most municipal street sweeping programs can be significantly improved by modifying the existing programs, in many cases at modest additional cost. Table III.3 sets forth a list of suggested methods for maximizing the pollutant removal effectiveness of street sweeping programs. The effectiveness of street sweeping can generally be improved by increasing the efficiency of the sweepers to remove pollutant loads from the street surface, by optimizing the frequency and extent of sweeping, and by reducing the accumulation of pollutant loadings on the street surface. Some of these suggestions address the frequency and scheduling of street sweeping, while others address the direct operation and maintenance of street sweepers or the type of equipment used. Others methods address related municipal public works activities or regulations which can help optimize street sweeping performance. The applicability of each of the suggested methods to an individual municipality is dependent upon the physical characteristics of the area and upon the existing sweeping program and related municipal operations. The evaluation of an existing street sweeping program should consist of three distinct elements: 1) a thorough understanding of local conditions that affect street sweeping effectiveness, 2) knowledge of the avantages and limitations of street sweeping methods and equipment, and 3) an understanding of how to modify the operation to incorporate desired improvements to obtain the maximum results with the resources available. Municipalities should initially consider those changes in their existing programs which can be most easily implemented at minimal cost.

DETENTION AND RETENTION BASINS

Description

Stormwater storage facilities may be classified as retention or as detention facilities. Retention facilities retain some of the captured water in a permanent pool which may be used for aesthetics or recreational purposes, including the maintenance of fish and aquatic and other wildlife. Excess water contributed during a storm event is generally temporarily stored, and then discharged to a receiving watercourse, or lost through evaporation or groundwater recharge. Detention facilities temporarily detain water during and immediately following a storm event and are generally drained completely between storm events.

There are a wide variety of stormwater detention techniques which can be provided in some urban settings at little cost to detain relatively small amounts of flow for short periods of time. These low-cost detention techniques consist of grassed stormwater collection swales designed to flow at low velocities thereby providing storage; small man-made depression areas designed to collect limited amounts of overland flow stormwater and permit it to infiltrate into the groundwater reservoir; and stormwater conveyance ditches designed to include check dams to reduce flow velocities and berms to provide increased storage volume. However, these low-cost measures often have limited applicability in established urban areas. Stormwater detention can also be provided on rooftops, in parking lots, in subsurface storage tanks, and in stormwater detention basins. A 1980 survey of over 12,000 storage facilities

Table III.3

METHODS OF MAXIMIZING THE POLLUTANT REMOVAL EFFECTIVENESS OF STREET SWEEPING PROGRAMS

Purpose	Method
1. To optimize the frequency and extent of street sweeping to provide the most cost-effective street sweeping schedule.	1. As soon as snow and weather conditions permit in spring, conduct an intensive sweeping program to sweep residential streets at least three times and commercial and industrial streets six to nine times to reduce high spring street surface loadings. 2. Conduct an intensive street sweeping program in fall to collect leaves and other vegetative debris. 3. Increase the frequency of sweeping those streets which have high pollutant loadings --primarily industrial areas--and which now are not swept often because litter problems are not severe.
2. To maximize the efficiency of the street sweeper to remove pollutant loadings from the street surface.	1. Develop, implement, and enforce regulations such as parking ordinances, litter controL and trash and refuse storage ordinances, and construction erosion control ordinances. 2. Educate and inform sweeper operators on how to optimize pollutant removals. Emphasize those factors (sweeper speed, brush adjustment and rotation rate, sweeping pattern, manuvering around parked vehicles, and interim storage and disposal methods) which have been shown to affect pollutant removal. 3. Use crimped wire or natural fiber brooms instead of plastic brooms, and maximize the broom pattern (The pattern is a measure of the pressure applied between the main pick-up broom and the street surface. It is measured as the tangential length of main pick-up broom in contact with the street surface).

Table III.3 (Continued)

Purpose	Method
	4. When new street sweepers are purchased, consider vacuum sweepers because some studies have indicated that vacuum sweepers remove a somewhat higher proportion of the fine particles and because vacuum sweepers can provide additional related uses such as leaf collection and catch basin cleaning. However, the replacement of still-effective mechanical sweepers with vacuum sweepers is not recommended.
3. To reduce the loading of pollutants on the street surface.	1. Eliminate the temporary storage of leaves in the street. Store leaves on the grassed right-of-way or in bags. 2. Establish a program for promptly sweeping special problem areas such as construction sites, special event areas, and high litter areas. 3. Maintain streets and provide smooth surfaces wherever possible. 4. Eliminate, or minimize, the duration of temporary storage of sweeper collected material on streets.
4. To generate public support to ensure continued adequate funding, and to inform residents of the benefits provided by street sweeping.	1. Educate the citizens and public officials on the multiple benefits of street sweeping, including aesthetics, water quality improvement, and air quality improvement by reducing fugitive dust emissions.

Source: SEWRPC

by the American Public Works Association indicated that nearly one half of the facilities surveyed were surface detention basins, with the second most common type of facility being parking lot detention facilities, comprising about one-fourth of the total (1981).

In general, the NURP studies which have evaluated stormwater storage as a nonpoint source control measure have concluded that stormwater retention basins, as indicated in Figure III.2, are effective in removing pollutants, but that traditional detention basins, which are drained completely by an outlet pipe located at the lowest point in the basin, do not remove a substantial amount of pollutants on a long-term basis (Driscoll, 1983). The study results indicated that detention basins did not store water during smaller storm events and accumulated sediments were flushed from the basin during subsequent storm events. However, detention basins can be modified with the use of perforated vertical pipe riser outlets or subsurface drains or other similar measures, thereby draining slowly and operating essentially as retention basins during and, for a period of time, following a storm event. A schematic diagram of detention basins modified with perforated vertical pipe risers and with subsurface drains is shown in Figure III.3. Other design criteria to maximize the pollutant removal effectiveness of detention basins are described in Table III.4, presented later in this chapter. Data based on particle settling velocities indicate that modified detention basins may be nearly as effective as are retention basins in removing pollutants (Northern Virginia Planning District Commission, 1980). This volume evaluates the feasibility, pollution abatement effectiveness, and cost of retention basins and of modified detention basins.

Objectives

Like street sweeping, retention and detention basins, in most instances, are currently not constructed primarily for water quality purposes. Most detention basins are constructed primarily to reduce downstream flooding problems and to reduce the size and cost of downstream drainage facilities. Most retention basins are also constructed primarily for flood control and drainage purposes, although aesthetic enhancement may also be an important objective. The removal of pollutant loadings, and the reduction in downstream streambank erosion and sedimentation of the stream channel are other important benefits of certain detention and retention basins.

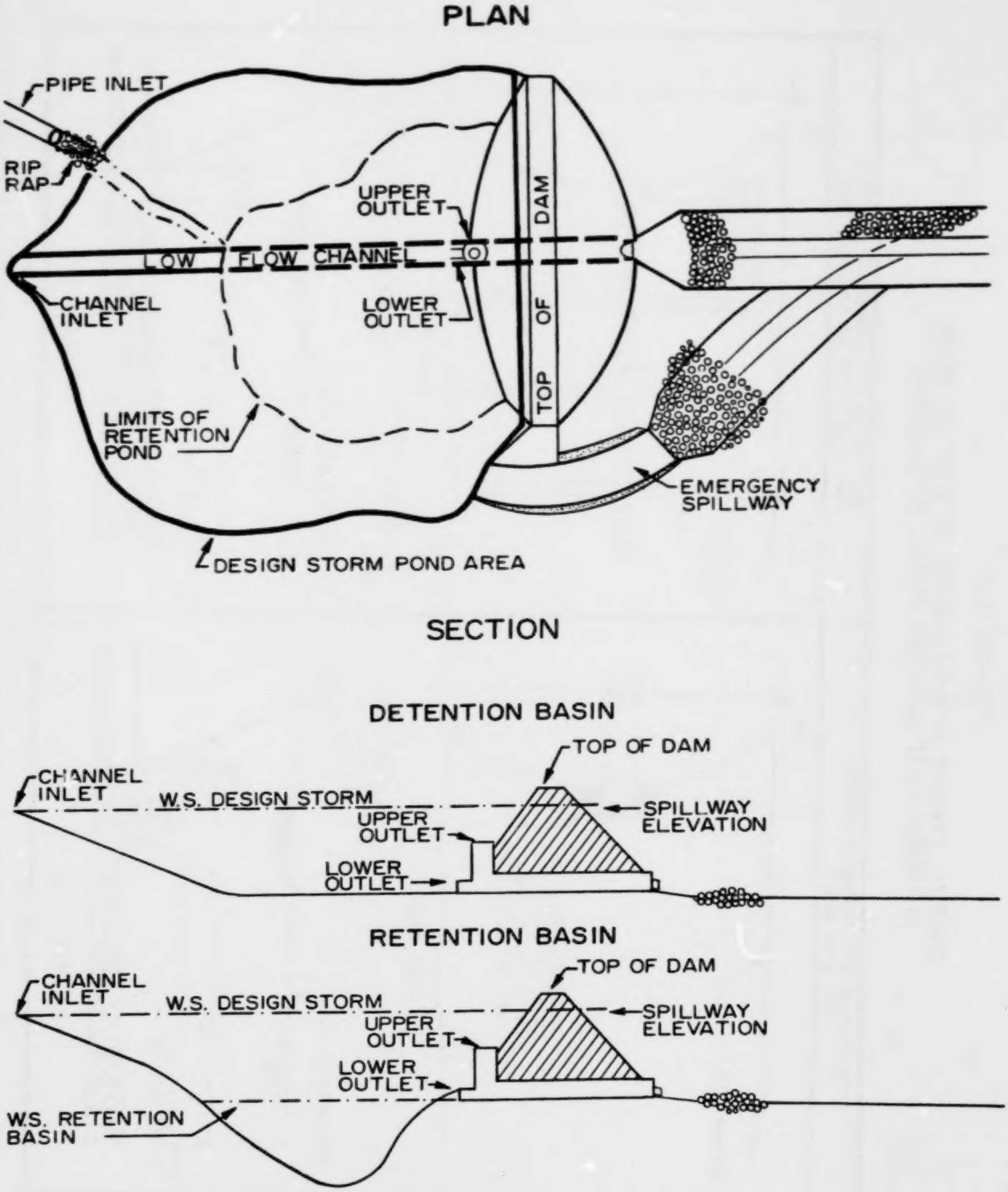
Importantly, the design specifications and size of a detention or retention basin, as well as its subsequent cost, are highly dependent upon the objectives of the basin. Basins designed for flood control during 10- to 100-year recurrence interval storm events may not function at all during smaller storm events and may achieve very low pollutant removal rates. For multipurpose detention or retention basins, it may be necessary to adjust the design parameters to compromise sometimes conflicting objectives. Downstream hydraulic impacts and the effects on flooding need to be considered in the design phase of both detention and retention basins.

Applicability

Modified detention basins and retention basins can be utilized in urban areas served by storm sewers as well as in those urban areas drained by open channels and roadside ditches. If increased urbanization of the drainage area is anticipated over the life of the basin, the increased runoff volumes and the water quality conditions resulting from this urbanization should be

Figure III-2

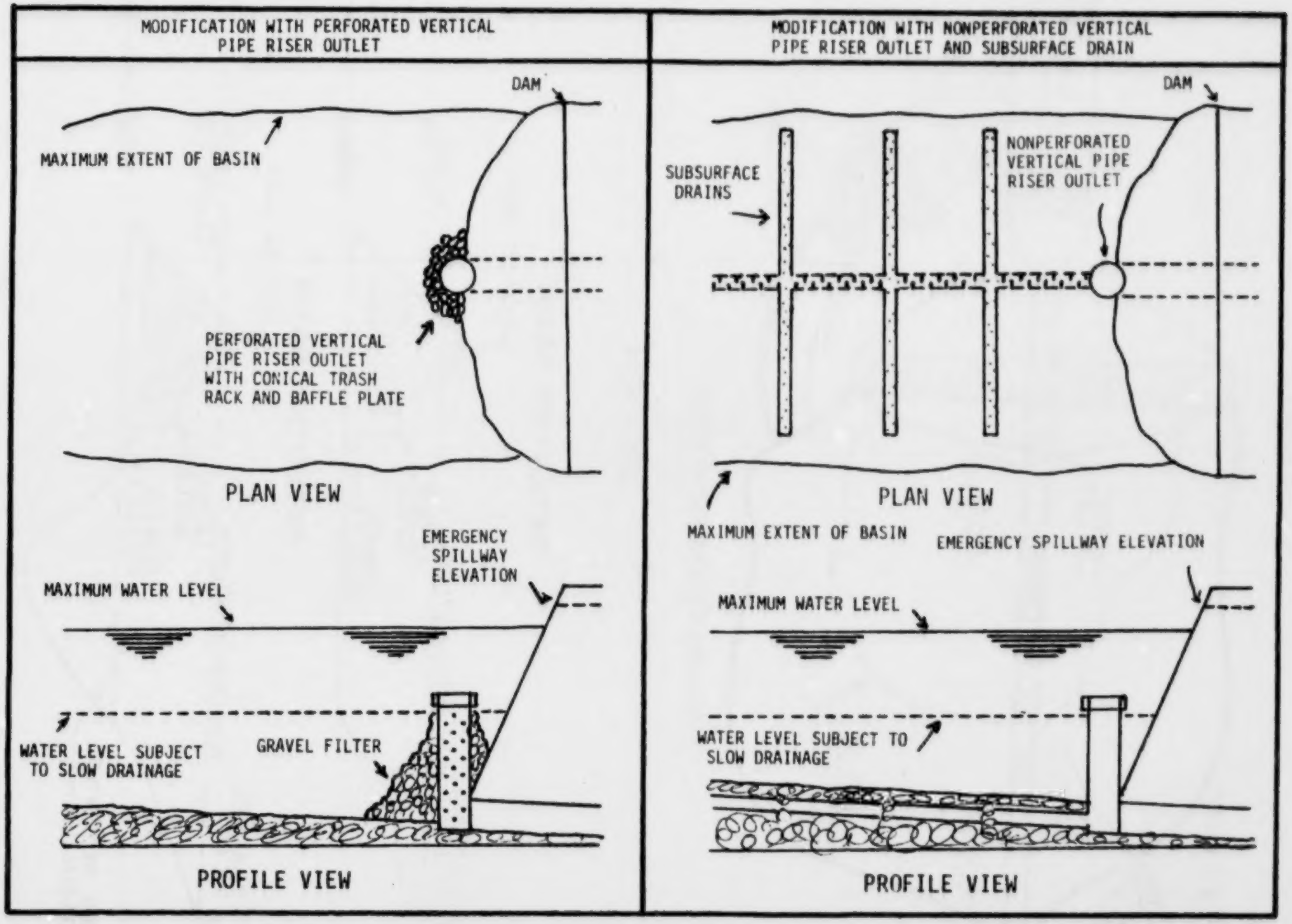
SCHEMATIC DIAGRAM OF A TYPICAL DETENTION BASIN AND RETENTION BASIN



Source: SEWRPC

Figure III.3

SCHEMATIC DIAGRAMS OF MODIFICATIONS TO DETENTION BASINS TO IMPROVE THEIR POLLUTANT REMOVAL EFFECTIVENESS


MODIFICATION WITH PERFORATED VERTICAL PIPE RISER OUTLET
DAM
MAXIMUM EXTENT OF BASIN
PERFORATED VERTICAL PIPE RISER OUTLET WITH CONICAL TRASH RACK AND BAFFLE PLATE
PLAN VIEW
EMERGENCY SPILLWAY ELEVATION
MAXIMUM WATER LEVEL
WATER LEVEL SUBJECT TO SLOW DRAINAGE
GRAVEL FILTER
PROFILE VIEW
MODIFICATION WITH NONPERFORATED VERTICAL PIPE RISER OUTLET AND SUBSURFACE DRAIN
DAM
SUBSURFACE DRAINS
NONPERFORATED VERTICAL PIPE RISER OUTLET
PLAN VIEW
MAXIMUM EXTENT OF BASIN
EMERGENCY SPILLWAY ELEVATION
MAXIMUM WATER LEVEL
WATER LEVEL SUBJECT TO SLOW DRAINAGE
PROFILE VIEW

Source: North Virginia Planning District Commission, Guidebook for Screening Urban Nonpoint Pollution Management Strategies, prepared for the Metropolitan Washington Council of Governments, 1980.

Table III.4

MODIFIED DETENTION BASIN AND RETENTION BASIN DESIGN CRITERIA TO MAXIMIZE THEIR POLLUTANT REMOVAL EFFECTIVENESS

Design Criteria	Description	Purpose
Proper Alignment of Inlet and Outlet	Locate outlet at the farthest feasible distance from the inlet	To prevent short-circuiting of flow and to force all of the storm runoff to pass through the entire basin
Adequate Basin Depth	Provide a stormwater storage depth of at least three to five feet in addition to the allowance for sediment accumulation between cleanings, and in addition to a permanent pool depth (for retention basins).	To prevent scouring and resuspension of the bottom sediments
Proper Basin Shape	Basins should be long and narrow--with a length to width ratio of at least 3:1--whereever possible	To force the inflowing water to travel as far a distance as possible to encourage settling of particulate pollutants.
Stabilization of Basin Bottom and Sides	Stabilize basin bottom and side slopes with sod, gabions, or riprap	To prevent sediment scouring and resuspension and to prevent erosion of the side slopes
Proper Inlet Control	Construct energy dissipators, filters, flow deflectors, and protective land cover at the basin inlet	To reduce flow velocities and turbulence in the basin, to control erosion at the inlet, and to filter out larger sized particles.
Proper Outlet Control	Construct outlet filters, and protective land cover at the basin outlet	To filter remaining particles before discharge from the basin and to prevent erosion at the outlet
Restriction of Outlet Flow for Detention Basins	Construct outlet structures, such as perforated vertical pipe risers, which allow the storage of storm runoff during both small and large storm events and which permit decreasing outflow as the basin water depth decreases	To allow settling of particulate pollutants during both small and large storm events and to capture the "first flush" of an event
Subsurface Outlet Flow for Detention Basins	As an alternative to the above restriction of outlet flow, utilize a non-perforated vertical pipe riser serving as the principal outlet, with subsurface drains located at a depth of 2 to 3 feet to slowly drain the pool	To allow the removal of both particulate and dissolved pollutants through filtration, adsorption, and biological activity through the soil profile

Source: SEWRPC

considered in the design and sizing of the basin. The potential future use of the basin site should also be considered.

To reduce the costs of the modified detention basins and retention basins, the basins may be located in existing open areas, usually on a small, intermittent stream or drainage ditch, or at a storm sewer outlet site. Natural depressions may be the most suitable sites, but excavation may be required. Compared to detention basins, retention basins will need to be sized larger to provide the same amount of storage, in order to accommodate the permanent pool. In highly developed urban areas, parks and parkways may represent the best sites for detention or retention basins. However, some urban areas will not have adequate basin sites available for surface detention or retention of stormwater. Other types of stormwater storage facilities must be considered in these areas.

Size or Extent of Operation

It is not the purpose of this chapter to describe the procedure for designing or sizing modified detention basins or retention basins. However, based upon the NURP study findings nationwide, some conclusions can be reached concerning the relative sizes and drainage areas of retention basins which may be expected to provide certain levels of pollutant removal. A similar relationship can be established for modified detention basins. Where land values are high and land uses intensive, the area available for stormwater detention or retention may be quite small. Design of a detention or retention basin therefore requires considerable engineering judgement in deriving the maximum benefit from as small an area as possible and in consideration of the needs and desires of the community. The size of the individual basins, relative to their drainage areas, determines the pollutant removal effectiveness of the basins, as well as the cost of the basins.

An important conclusion of those NURP studies which evaluated retention basins is that relatively small basins can remove a high percentage of the inflowing pollutant loads from relatively large tributary drainage areas. As described below, it was concluded that this same relationship between basin size and drainage area and pollutant removal effectiveness also exists for modified detention basins. To provide at least a 50 percent reduction in the suspended solids load entering the basin, the basin surface area should be no less than about 0.1 percent of the area of the tributary drainage area (Driscoll, 1983). For example, a one-acre detention basin should receive drainage from not more than a 1,000-acre tributary area. If significantly higher levels of pollutant removal are desired, one acre of modified detention or retention basin should be provided for every 250 to 500 acres of tributary area. Retention basins should have a minimum permanent pool depth of from three to five feet, with additional depth provided for stormwater storage, and modified detention basins should have a minimum total depth of from three to five feet to prevent resuspension and scouring of the collected sediments on the basin bottom.

For a given basin size, the basin outlet should be designed and sized for a selected recurrence interval storm. The design storm inflow hydrograph is determined from watershed characteristics and climatological data. A survey of 26 design firms conducted by the American Public Works Association in the early 1970's indicated that 22 of the firms, or 85 percent, used the rational method in their design of stormwater detention basins.

It is, however, generally recognized that the rational method formula has limitations for use in designing detention or retention basins. Other methods such as the unit hydrograph method and mathematical simulation models may also be used to develop inlet and outlet hydrographs and to determine storage volumes. A review of methods of computing stormwater runoff rates volumes and hydrographs is set forth in Urban Stormwater Management, Special Report No. 49, published by the American Public Works Association in 1981.

Because of the high--50 percent to 90 percent or more--reductions in pollutant loads achievable by properly designed modified detention and retention basins, it is often not necessary that all of the land area within a municipality drain to a modified detention or retention basin in order to achieve the desired water use objectives and supporting water quality standards. In many municipalities within southeastern Wisconsin, less than one half of the urban area may need to drain to modified detention basins or retention basins to meet the recommended water quality standards for most pollutants, even if modified detention basins or retention basins were the only nonpoint source control measure applied.

Problems

Unlike street sweeping, which is currently used by essentially all of the larger municipalities, only a limited number of detention or retention basins have been constructed in southeastern Wisconsin, and many municipalities may have, or at least perceive to have, severe constraints on the use of detention or retention basins. Some of these constraints concern the physical requirements of the site, while others concern the design and management of the basin.

In established urban areas, often one of the most important limitations is the availability of suitable land for a modified detention basin or a retention basin. Many urban areas may not have open land areas which are located on a waterway and which are not suitable for more desired uses. The use of several potential residential building lots or expensive commercial sites for stormwater storage basins is often not accepted by local citizens or public officials. Poor soils, unfavorable topography, high groundwater, or the presence of environmentally-sensitive high quality wetlands or wildlife habitat may also preclude the construction of a detention or retention basin on some sites. The location and alignment of existing and proposed streets, utilities, buildings and recreational facilities may also limit the suitable areas for basins.

Some existing detention or retention basins receive maintenance only when serious problems become evident, or when a local unit of government begins to receive complaints. The lack of a regularly scheduled maintenance program may reduce both the pollution control and flood control benefits of a basin and create aesthetic nuisance and safety hazard conditions. Retention basins may support nuisance growths of aquatic weeds and algae, breed mosquitoes, producing foul odors and poor aesthetics. A 1980 survey by the American Public Works Association of 219 public agencies indicated that the five most prevalent maintenance problems associated with detention and retention basins were weed growth, grass maintenance, sedimentation, bank deterioration, and mosquito control (APWA, 1981). Experience with the operation of hundreds of detention basins in Atlanta, Georgia indicated that (Debo and Ruby, 1982):

- Access for maintenance is difficult for many detention basins.
- Detention basins are often designed with steep banks where vegetation is difficult to establish and maintain.
- Outlet structures are prone to clogging which results in stagnant pools of water remaining for long periods of time.
- The basins may become depositories for urban litter and trash.
- Weed control is difficult, especially when the basins do not drain dry after each event.
- Fences and landscaping are often damaged or destroyed.

Closely associated with maintenance problems are certain health and safety hazards related to detention and retention basins. In Atlanta, Georgia, stagnant pools of water and moist ground became mosquito breeding areas and attracted rodents and other pests. Accumulated litter and trash can pose a safety hazard for children. Retention basins in particular, may pose a safety hazard to children attracted to the site, necessitating fences to restrict access. These fences, however, may be unsightly, difficult to maintain, and prone to vandalism.

Although it is usually assumed that storing peak flow discharges and discharging at a lower flow for a longer period of time will decrease flooding problems downstream, if several modified detention or retention basins are installed in one drainage area, the timing of flood discharges will be changed. This can combine flows and actually increase the peak flows in some areas. Flood routing analyses are needed to ensure that downstream flooding problems are not increased.

Public acceptance of modified detention basins and retention basins may be a problem, especially if the basins are poorly designed, inadequately maintained, or littered. A survey of residents in the Atlanta, Georgia area living adjacent to, or downstream of, fifteen small detention basins indicated that the most common complaints were poor appearance of the detention basin, silt and trash accumulation, concern for children's safety, mosquitoes, rats, snakes, and foul odors (Debo and Ruby, 1982). A lack of basin maintenance was common in the Atlanta area and most residents surveyed were unaware of the purpose or benefits of the basins. However, in spite of a lack of public acceptance for detention basins in some areas, it has been reported that surface storage basins are generally more acceptable to the public than are other stormwater storage facilities such as parking lot or rooftop storage structures and undergound storage facilities (APWA, 1981).

Where detention basins are modified so they are equipped with subsurface drains, there is a potential for clogging the soil profile, preventing infiltration into the soil. The Northern Virginia Planning District Commission (1980) evaluated this potential problem and concluded that as long as adequate drying of the basin occurs, clogging due to solids accumulation should not be a problem. In addition, the maintenance of bottom vegetation, such as Bermuda grass which is used as a cover in rapid infiltration basins due to its ability to tolerate inundation for extended periods, should help maintain pore spaces and infiltration rates, thereby reducing the prospects of clogging.

Many of the potential problems can be minimized or eliminated by use of proper hydrologic-hydraulic analytical techniques and design procedures, and by a carefully developed long-term maintenance program. The evaluation of alternative modified detention basin and retention basin types, sites, or sizes should consider the hydraulic, economic, social, and political consequences, as well as a determination of the water quality benefits of the basins.

Pollution Abatement Effectiveness

Modified stormwater detention basins and retention basins operate essentially as settling ponds during and immediately following storm events. The level of pollutant removal achieved is related to the size of the pollutant particulates entering the basin and to the detention time. Required settling times range from a few minutes for sand-sized particles to several days for fine clay-sized particles. The pollutant removal estimates for retention basins presented below assume that the removal process is primarily a physical one, and that biological activity does not, therefore, remove a significant portion of the load. It is also assumed that scouring of the accumulated sediments will be prevented by proper design and maintenance of the basin.

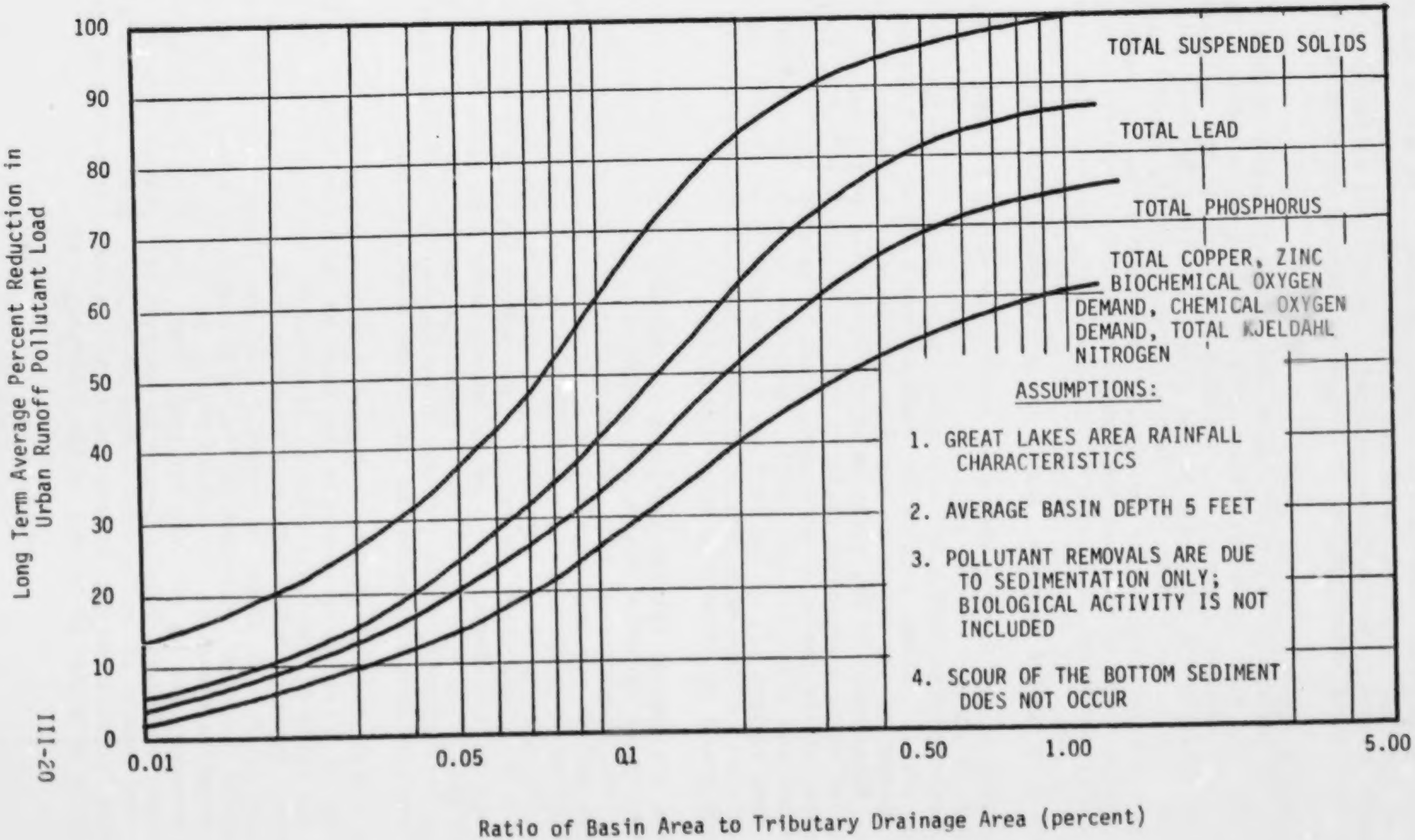
Analysis of preliminary NURP data reported by Driscoll (1983) indicates that about 10 percent of the particles in urban runoff are sand-sized, having a diameter greater than 0.062 millimeter (mm). About 65 percent of the particles are silt-sized, ranging in diameter from 0.062 mm to 0.004 mm, and about 25 percent of the particles are clay-sized, having a diameter less than 0.004 mm. Measurement of the particle size distribution of the material carried in the inflow to a retention basin in Lansing, Michigan indicated that about 14 percent of the particles were sand, about 69 percent were silt, and about 17 percent were clay (U.S.EPA, 1982). Therefore, if sufficient detention time is allowed so that all of the sand and a large portion of the silt particles can settle out, a high--more than 50 percent--reduction in the inflowing pollutant loads should be achieved by retention basins.

There are several methods available for estimating the removal efficiency of detention or retention basins for suspended solids. Some methods are simple, requiring knowledge of only the basin size and the drainage area; whereas, other methods are more sophisticated, involving the use of mathematical simulation models which consider variables such as particle size distribution, the specific gravity of the particles, settling velocities, basin geometries, and outlet structure sizes and types. Some methods are capable of estimating the removal effectiveness for some pollutants other than total suspended solids (see Chapter 12 of APWA, 1981). A simplified method developed with NURP study data is presented herein for use in evaluating the pollutant removal effectiveness of retention basins at the systems planning level.

The method which is applied in Chapter V of this volume involves the use of a series of curves which indicate the level of pollutant removal as a function of the ratio of the basin area to the tributary drainage area. The series of curves, based on NURP study data from the Great Lakes area are set forth in Figure III.4. As shown in Figure III.4, the highest level of removal is achieved for total suspended solids, with a maximum removal rate of more than 95 percent achievable. The second highest maximum level of removal--more than 85 percent --can be achieved for total lead. The third highest maximum level of removal --about 75 percent--can be achieved for total phosphorus. Removals of the remaining pollutants evaluated--copper, zinc, biochemical oxygen demand, chemical oxygen demand, and total Kjeldahl nitrogen--can range up to slightly more than 60 percent of the inflowing loads.

Figure III.4

THE POLLUTANT REMOVAL EFFECTIVENESS OF RETENTION BASINS
IN THE GREAT LAKES AREA



Source: Driscoll, 1983.

The figure indicates that a relatively high level of pollutant removal can be achieved by a relatively small retention basin receiving urban runoff from a comparatively large drainage area. For example, a one-acre retention basin draining a 500 acre tributary area may be expected to remove, on an annual basis, over 80 percent of the suspended solids, over 60 percent of the lead, over 50 percent of the phosphorus, and about 40 percent of the copper, zinc, oxygen-demanding substances, and total Kjeldahl nitrogen. These pollutant removal estimates assume that the basin is properly designed, that no bottom scouring occurs, and that the basin is properly maintained and cleaned.

The curves shown in Figure III.4 are based on an average permanent pool depth of five feet and on rainfall characteristics in the Great Lakes area. The curves are thus suitable for the systems level analyses presented in Chapter V. For more detailed engineering analyses, however, the curves should be modified to reflect local rainfall characteristics, proposed basin depths and design features, and urban runoff characteristics.

The water quality effectiveness of modified detention basins was evaluated by comparing the results of a study by the Northern Virginia Planning District Commission (NVPDC) to the pollutant removal curves for retention basins shown in Figure III.4. The NVPDC study evaluated the pollutant removal effectiveness of detention basins modified as shown in Figure III.3, using the settling velocities of various sized particles (NVPDC, 1980). The comparison indicated that modified detention basins can remove about the same portion--within 5 percent--of the loads of those pollutants not subject to biological uptake or decomposition--suspended solids, lead, and zinc--as can retention basins of the same storage size. However, for those pollutants subject to biological uptake or decomposition--total phosphorus, total Kjeldahl nitrogen, and biochemical oxygen demand--retention basins appeared to remove 20 to 40 percent more of the loads than could modified detention basins. An analysis of the NVPDC data indicated that an approximate 20 percent lower portion of the load of these biologically -active pollutants was assumed to be settleable, than was assumed in the NURP data used to derive Figure III.4. This accounts for some of the difference in removal rates between modified detention basins and retention basins. If the NVPDC results are adjusted to reflect the settleable fractions identified in the NURP studies, the modified detention basins then appear to work essentially as effectively as do retention basins for all pollutants except phosphorus, for which retention basins remove from 15 to 20 percent more than would a similarly-sized modified detention basin. If the modified detention basin is drained by a subsurface drainage system, the increased removal efficiency provided by filtration through the soil profile was not considered in the NVPDC analysis; only settling in the basin was considered. Therefore, based on this comparison, it may be assumed that modified detention basins have about the same pollutant removal efficiency as retention basins of the same storage size. Hence, the pollutant removal curves set forth in Figure III.4 for retention basins may also be applied to modified detention basins.

Administration and Management

The planning, design, and operation and maintenance of retention and modified detention basins is complex and requires consideration of numerous factors other than water pollution control, such as regulatory requirements, location considerations, downstream hydraulic effects, safety measures, nuisance control, ownership and access arrangements, property values, and financing arrangements. In particular, detailed hydrologic-hydraulic analyses need to be conducted to determine storm drainage patterns and runoff flows during various recurrence interval storm events, the hydraulic capacities of upstream and downstream conveyance facilities, flood levels and stages, and hydraulic design requirements. In newly developing areas, detention and retention basins can be best located, sized, and designed within the context of a comprehensive stormwater management plan (SEWRPC, 1983).

In general, modified detention or retention basins located on public property are constructed and maintained by public agencies, whereas basins located on private property are usually constructed and maintained by the private landowners. However, a review of a number of stormwater management programs in the country indicates a trend towards assumption of greater public agency responsibility for detention and retention basin maintenance (Metropolitan Washington Council of Governments, 1983). A principal reason for this trend appears to be a desire for better maintenance programs. Local units of government bear the greatest responsibility for stormwater management, can best determine the community's needs and preferences, and are the most likely source of needed funding for proper maintenance of the basins. It may be impractical to hold private property owners responsible for the full range of maintenance functions required to keep the basins operating as designed over their useful life, particularly when major corrective or structural repairs are involved (Metropolitan Washington Council of Governments, 1983). Factors cited in this regard include the transient nature of private ownership, the limited funds and expertise of private entities to perform major maintenance, and an inability to respond to emergency situations. At a minimum, periodic basin inspections by a public agency are recommended. Maintenance activities can be monitored, and technical advice on maintenance needs can be provided by a public agency. If a private landowner responsible for basin maintenance is unwilling or unable to provide such maintenance, provisions can be made under the terms of which the public agency may provide the proper maintenance services and then charge the landowner for the service provided.

Detention basin and retention basin design and maintenance may be governed by municipal ordinances. Good land subdivision control ordinances contain requirements that a stormwater drainage system be provided as a condition of plat approval. Some communities have enacted ordinances requiring that stormwater runoff after the development not exceed runoff prior to the development; in essence, requiring stormwater storage. However, this type of broad "policy planning" may create more problems than it solves, and even the intended flood control benefits may not result (Debo and Ruby, 1982).

Local units of government can achieve the maximum level of pollution reduction from detention basins and retention basins by ensuring that proper design criteria and management measures are followed. Figure III.4 presented the pollutant removal effectiveness of retention basins based on the ratio of the basin area to the tributary drainage area. As already noted, this same pollutant removal relationship may also be applied to modified detention basins. Certain modifications can be made in the design and construction of the modified detention basins and retention basins to ensure that, at least, the pollutant removal rates shown in Figure III.4 are achieved. Table III.4 presents design criteria for maximizing the pollutant removal effectiveness of modified detention basins and retention basins. Some of the design criteria involve providing proper basin shape, depth, and side-slopes to prevent bottom sediment scouring and resuspension, to control erosion of the basin side-slopes, and to maximize the flow path of the stormwater. Other design criteria address the proper location, type, and size of inlet and outlet structures.

The operation and maintenance of a modified detention basin or a retention basin also affect pollutant removal effectiveness. The accumulated sediment must be removed often enough to prevent bottom scouring and to maintain the required basin volume. Exposed soil surfaces and soil erosion should be minimized. The associated structures--particularly the basin outlet and inlet--should be maintained to operate according to designed specifications. Importantly, the basin should be kept in an attractive appearing and nuisance-free condition and any problems should receive prompt attention in order to maintain public and political support for continued operation and maintenance of the basin, as well as to help encourage the construction of new basins elsewhere, where appropriate as a pollution control measure or for other purposes.

CATCH BASINS

Description

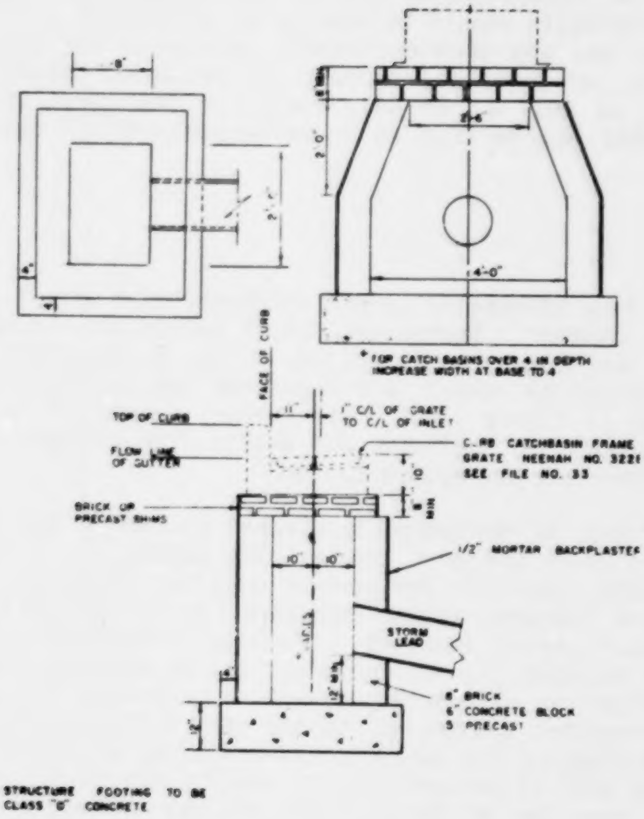
A catch basin is a stormwater runoff inlet equipped with a small sedimentation basin or grit chamber. Stormwater runoff enters the catch basin through the surface inlet and drops to the bottom of the basin, where sediment and other debris transported by runoff are deposited and accumulate. A typical catch basin is shown in Figure III.5. The primary purpose of the catch basin is to provide for removal of sediment and debris from stormwater runoff before it enters the subsurface conveyance system.

Catch basins must be periodically cleaned to remove the sediment and debris which accumulates in the grit chamber. The basins can be cleaned either manually, or by using specially designed or modified equipment including specially designed bucket loaders, vacuum eductors, or vacuum attachments utilized in conjunction with street sweepers. Cleaning frequencies are generally determined by the availability of equipment and/or manpower in a given community and a determination by the department responsible for maintenance of the stormwater management system, as to the need for cleaning the basins. A 1973 APWA survey evaluated the public works practices of 61 municipalities nationwide and found that 41 percent cleaned their catch basins annually and 26 percent cleaned them two or three times per year (APWA, 1978). A 1976 public works practices survey of 14 cities in southeastern Wisconsin conducted by the Regional Planning Commission as part of its areawide water quality management planning effort indicated that all but one municipality periodically cleaned their catch basins (SEWRPC, 1977). The cleaning frequencies in southeastern Wisconsin ranged from once every three years to twice per year. Of the 13 cities which cleaned their catch basins, five cleaned them manually and the remaining eight cities cleaned them with a vacuum attachment to a street sweeper. Both of the aforereferenced evaluations concerning catch basin cleaning reported that material removed from the basins was disposed of at landfills.

During storm events, some of the accumulated pollutants may be flushed from catch basins into the storm sewer systems. This flushing reduces the amount of material which is accumulated, and also the pollutant removal efficiency of

Figure III.5

TYPICAL STORMWATER CATCHBASIN



Source: Standard Specifications for Sewer and Water Construction in Wisconsin, Fourth Edition, March 1, 1980.

the catch basins. Increasing the frequency of cleaning so that sediment and debris is removed when approximately 50 percent of the total grit chamber capacity is reached, will serve to reduce the flushing of the accumulated sediments (Ontario Ministry of the Environment, 1977).

Objectives

Catch basin cleaning has historically been undertaken to remove accumulated debris to prevent clogging of downstream stormwater conveyance systems. The removal of decaying debris and highly polluted water from catch basins also has aesthetic and cosmetic benefits, prevents the discharge of foul odors, and reduces high pollutant concentrations during the "first-flush" of a stormwater runoff event. Because of the cost associated with catch basin cleaning, and the potential negative impacts on water quality and odors if the basins are not adequately cleaned, catch basins are generally no longer constructed as components of piped storm sewer systems. The use of catch basins may be warranted, however, in areas generating unusually high amounts of sediment and debris, to prevent pollutants from being contributed to receiving waters.

Applicability

Surveys conducted by the Regional Planning Commission as part of its areawide water quality management planning efforts indicated that the extent of the use of catch basins varies markedly throughout the Region, with some communities having storm sewer systems without any catch basins while others have essentially all of the storm sewers equipped with catch basins (SEWRPC, 1977). Most existing medium to high density urban development within the Region is, however, served by storm sewers equipped with catch basins. In such areas, there are generally between 12 and 18 catch basins per curb mile of street.

Catch basin cleaning is required if the basins are to perform properly. The frequency of cleaning may be influenced by the type of cleaning equipment available to the municipality. The use of stormwater inlets instead of catch basins is intended to reduce maintenance costs. With such inlets the debris and sediment are flushed through the subsurface transport system with each rainfall event, rather than accumulating in the bottom of the catch basins. While this does reduce maintenance requirements, it provides no pollution abatement.

Size or Extent of Operation

Although a variety of techniques, including manual labor, vacuum eductors, and bucket machines, are utilized to clean catch basins, labor-intensive manual cleaning methods are generally utilized in smaller communities, or for specialized situations in larger communities where vacuum eductors, or bucket machines cannot be utilized. The results of a 1973 survey by the American Public Works Association indicated that the majority of catch basins were cleaned with vacuum eductors or bucket machines (APWA, 1978). The survey indicated that an average of about 10 basins could be cleaned per day by a 3 or 4-man manual cleaning crew, whereas, about 20 basins could be cleaned per day by a 2 or 3-man crew using vacuum eductors, or bucket machines. As already noted, there are generally between 12 and 18 basins per curb mile in urban areas.

The American Public Works Association survey also indicated that there were approximately 25,000 catch basins in the City of Milwaukee, and that they were cleaned once every three years. Cleaning techniques utilized in Milwaukee included manual labor, bucket machines, and vacuum eductors.

Problems

The efficiency of a catch basin cleaning program in any given municipality is influenced to some degree by the amount of pollutants which accumulate in the basins, by the physical characteristics of those portions of the community which drain to these basins, by traffic and parking patterns, and by the method of cleaning. Streets and alleys with catch basins which are too narrow to accommodate cleaning equipment, necessitate that smaller less conventional machines be utilized, or that they be cleaned by hand. Traffic and parking patterns can restrict access to catch basins. Cleaning schedules and/or alteration of traffic and parking patterns may be necessary to ensure that the basins in a given area are periodically cleaned. Basins which are in need of repair, clogged with debris, or which are full of water may also preclude the use of more efficient equipment or may require repair or rehabilitation before they can be cleaned.

Climate, particularly snow and ice, restricts or precludes catch basin cleaning in the winter. The accumulation of additional debris in basins as a result of reduced street sweeping and related cleanup practices during winter, and which has been transported by stormwater runoff in the spring, may necessitate an increased cleaning effort in spring. Careful scheduling of such intensified basin cleaning may be required to minimize any conflicts with other public works projects or programs that require the same equipment as that utilized for basin cleaning, or other maintenance activities.

Pollution Abatement Effectiveness

Catch basins are relatively effective in trapping larger particles and debris transported by stormwater runoff (Sartor and Boyd, 1972). The grit chambers in most catch basins have a capacity of between 0.5 and 1.5 cubic yards of material. Data collected as part of the NURP project in Castro Valley Creek, California, indicated that basins which had been cleaned either once per year or once every other year, contained approximately 60 pounds of material each (Pitt and Shawley, 1981), although many catch basins have the capacity to hold over 1,000 pounds of material. The rate at which catch basins fill with debris, as well as the total amount of material which can be removed by different frequencies of catch basin cleaning are highly variable and cannot be readily predicted using the NURP study data. In addition, some of the debris which is trapped in catch basins, such as rocks and cans, may not properly be considered water pollutants, although such debris may interfere with the use of the receiving waters.

In the absence of cleaning, catch basins may actually make water quality conditions worse than if the catch basins did not exist. The material which accumulates in catch basins undergoes decay, and the first flush of stagnant water and debris by the stormwater runoff in the sewer system may contain high concentrations of pollutants. Average concentrations of pollutants in catch basin liquid discharged during storm events are similar to concentrations of untreated sewage (Lager and Smith, 1974).

Thus, although it is not possible, based on the data currently available, to quantify the water quality benefits of catch basin cleaning, such cleaning does provide benefits. These benefits include the removal of pollutant loads from the sewer system, the reduction of high pollutant concentrations during the "first flush" of a storm event, and prevention of clogging of the downstream stormwater conveyance system.

Administration and Management

Catch basin cleaning programs are usually carried out by street and highway departments. A 1975 American Public Works Association survey indicated that catch basin and inlet cleaning was conducted by street and highway departments in 70 percent of the 96 cities surveyed (APWA, 1978). The remaining 30 percent of the communities surveyed assigned catch basin cleaning to a variety of municipal departments including those responsible for sewers, public works, engineering, and sanitation.

As previously discussed, the most efficient and widely utilized method of catch basin cleaning requires the use of either specialized equipment or machinery sometimes used in conjunction with other equipment such as street sweepers. The use of such equipment requires that scheduling and coordination of public works and street maintenance activities be carefully planned to ensure that the maximum use of the equipment and the associated benefits of basin cleaning be accrued.

The determination of appropriate catch basin cleaning frequencies and schedules in order to maximize the benefits provided can be based upon the rate at which the catch basins fill. In most areas, it is likely that all basins may be cleaned once each spring, preferably before major spring rainfalls. Basins in high sediment and debris loading areas may be cleaned more frequently.

Chapter IV

ECONOMIC ASPECTS OF URBAN NONPOINT SOURCE POLLUTION CONTROL

INTRODUCTION

In the implementation of urban nonpoint source pollution control measures, local units of government may encounter costs for administration, planning and design, land acquisition, construction, and operation and maintenance. The magnitude of these costs are dependent upon the local conditions, type of control measures, existing and proposed future land uses, environmental considerations, and public and political preferences. Some of these nonpoint source control costs may be included in expenditures for existing public works operations, such as street sweeping and catch basin cleaning; other costs may be included in expenditures by local units of government in carrying out their responsibilities to provide stormwater management systems; while still other costs may be incurred for new pollution abatement measures such as construction site erosion control practices. Some costs for nonpoint source control may also be incurred by private landowners and by land developers.

This chapter provides data on the costs of street sweeping, modified detention basins and retention basins, and catch basin cleaning as nonpoint source pollution control measures. To the extent possible, the distribution of these costs between capital expenditures and operation and maintenance are provided. Unit costs are provided to facilitate the calculation of nonpoint source control costs associated with system plans. Costs to improve or optimize the pollutant removal effectiveness of each of these measures are also provided.

STREET SWEEPING

Street sweeping is a relatively labor-intensive public works operation which also requires a substantial investment in sweeper trucks, disposal facilities, and maintenance facilities. A typical mechanical street sweeper costs about $45,000 or more, in 1981 dollars, and has an economic life of about eight years (Bureau of Budget and Management Analysis, City of Milwaukee, 1976). In addition to capital costs and labor costs, street sweeping operations require funds for maintenance, parts and materials, fuel, and disposal fees. An evaluation of the effects that altered schedules and different frequencies of sweeping have on existing street sweeping costs requires that total public works expenditure data be examined, that the distribution of public works and street sweeping expenditures be determined, and that unit costs for street sweeping be identified.

While street sweeping is one of the more observable and well-known public works operations conducted by many counties, cities, and villages, it comprises a relatively small portion of the total public works budget for most municipalities. Table IV.1 sets forth expenditures for various public works activities for 1978 reported by the seven counties, 28 cities, 54 villages, and 65 civil towns in southeastern Wisconsin to the Wisconsin Department of Administration, Bureau of Municipal Audit. As shown in the table, about $318 million was spent on public works operations in southeastern Wisconsin in 1978. Street sweeping operations accounted for about $2.8 million, or about

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Table IV.1

PUBLIC WORKS EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN SOUTHEASTERN WISCONSIN BY COUNTY: 1978[a]

County	Street Sweeping: Street Sweeping Expenditure	Street Sweeping: Percent of Region Street Sweeping Total	Street Sweeping: Percent of County Total Public Works Expenditure	Transportation	Sanitation	Subsidies[b]	Enterprises[c]	Capital Projects[d]	Special Assessment Funds[e]	Total
Kenosha	$ 129,200	4.6	1.3	$ 6,262,900	$ 1,281,000	$ 556,700	$ 1,244,200	$ 303,400	$ 0	$ 9,777.400
Milwaukee	1,947,200	70.1	1.1	74,012,200	31,024,000	611,100	33,969,100	36,025,800	5.818,600	183,408,000
Ozaukee	110,700	4.0	0.3	5,840,200	1,122,200	12,800	6,028,500	16,925,400	1,611,100	31.650 900
Racine	295,800	10.6	1.5	8,844,700	2,903,100	1,432,500	4,734,400	1,721,200	0	19.931,700
Walworth	74,000	2.7	0.3	6,026,400	718,200	1,105,900	9,044,800	5,736.200	660,200	23.365.700
Waukesha	196,000	7.0	0.5	14,652,700	3,431,100	6,252,000	10,516,300	2,553,900	503,100	38,105,100
Washington	26,600	1.0	0.2	5,822,100	914,600	985,900	2,237,000	1,417,400	0	11,403 600
Total	$2,779,500	100.0	0.9	$121,461,200	$41,394,200	$10,956.900	$67,774,300	$64,383,300	$8.593,000	$317 642,400

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[a] For the purposes of this analysis public works includes all services related to sanitation, transportation, and sewerage and water systems.

[b] Subsidies include expenditures for water and sewer utilities, mass transit, and solid waste management.

[c] Enterprises include expenditures for airports, parking, sewer and water utilities, mass transit and solid waste management.

[d] Capital projects include expenditures for street and highway construction/reconstruction, highway buildings and equipment, storm sewers and sanitation.

[e] Special assessment funds include expenditures for street, sidewalks, curbs and gutters, storm sewers, and sanitary sewers.

Source: Wisconsin Department of Administration and SEWRPC.

1 percent of the total public works expenditures. The percent of the total public works expenditures used for street sweeping was slightly higher--up to 1.5 percent--for Milwaukee, Racine, Kenosha, and Waukesha Counties, which are more highly urbanized than Ozaukee, Walworth, or Washington Ccunties. The percent of the total expenditures attributed to street sweeping was lower--as little as 0.2 percent--for the most rural counties--Walworth and Washington Counties. About 70 percent of the total street sweeping expenditures in southeastern Wisconsin was made by the local units of government in Milwaukee County. Local units of government within Milwaukee County accounted for 58 percent of the total public works expenditures in southeastern Wisconsin.

Compared to other municipal public works operations, street sweeping is more labor-intensive and generally requires a lower capital outlay. Table IV.2 sets forth the distribution of public works expenditures by the above-noted local units of government in southeastern Wisconsin in 1978. While only 28 percent of the total public works expenditures were for wages and fringe benefits, such wages and fringe benefits accounted for 44 percent of the total street sweeping expenditures. Of the remaining six public works categories, only sanitation was more labor-intensive, with 47 percent of its total expenditures allocated for wages and fringe benefits. Capital outlay accounted for 27 percent of the total public works expenditures, but for only 4 percent of the street sweeping expenditures. More than one-half of the total street sweeping expenditures were in the "Other" category, which includes maintenance, parts, fuel, and disposal costs.

Annual hours worked, street miles swept, amount of material collected, and total costs for the City of Milwaukee street sweeping program over the period of 1976 through 1980 are shown in Table IV.3. Unit costs in dollars per hour worked, dollars per cubic yard of material collected, and dollars per curb mile of street swept are also shown in the table. Unit costs per hour worked, cubic yard collected, and mile swept increased by 80 percent, 87 percent, and 60 percent, respectively, over the period of 1976 through 1980. Unit costs based on the amount of material collected for alley sweeping were generally higher than for street sweeping, but unit costs for hours worked or curb miles swept were generally equivalent for alley sweeping and street sweeping. This indicates that lower amounts of material were collected from each typical mile of alley swept than were collected from each typical curb mile of street swept.

A comparison of the distribution of street sweeping costs and unit costs from several NURP studies, as well as from other sources available, are presented in Table IV.4. In general, the distribution of costs and the unit costs estimated from the Milwaukee NURP study data are consistent with the results of the other NURP studies evaluated, as well as with studies or surveys not conducted under the Nationwide Urban Runoff Program. Wages, salaries and indirect labor costs comprised from 33 percent to 74 percent of the total street sweeping costs, with a mean of 50 percent. Maintenance and materials accounted for 11 percent to 56 percent of the total costs, with a mean of 28 percent. Fuel, equipment depreciation, and disposal costs each averaged less than 10 percent of the total cost, and each always comprised less than 20 percent of the total cost.

Unit costs, which include capital and operation and maintenance costs, are presented in Table IV.4 for each pound of solids collected, cubic yard of solids collected, curb mile swept, and hour of sweeper operation. Costs per

Table IV.2

DISTRIBUTION OF PUBLIC WORKS EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN SOUTHEASTERN WISCONSIN: 1978[a]

	Street Sweeping		Transportation		Sanitation		Subsidies[b]	
Category	Expenditure	Percent of Total	Expenditure	Percent of Total	Expenditure	Percent of Total	Expenditure	Percent of Total
Wages & Fringe Benefits......	$1,228,100	44	$ 46,860,700	38	$19,651,200	47	$ 0	0
Other..........	1,449,700	52	56,844,000	47	20,483,200	49	8,806,700	80
Capital Outlay.	101,600	4	17,131,200	14	1,123,800	3	0	0
Inter-Fund Transfers.....	100	1	625,300	1	136,000	1	2,150,200	20
Total	$2,779,500	100	$121,461,200	100	$41,394,200	100	$10,956,900	100

-Continued-

Table IV.2 (Continued)

Category	Enterprises[c]		Capital Projects[d]		Special Assessment Funds[e]			
	Expenditure	Percent of Total	Expenditure	Percent of Total	Expenditure	Percent of Total	Total	Percent of Total
Wages & Fringe Benefits......	$19,407,000	29	$ 223,400	1	$ 0	0	$ 87,370,400	28
Other..........	36,928,900	54	3,492,900	5	69,100	1	128,074,500	40
Capital Outlay.	1,431,500	2	56,504,600	87	8,427,400	98	84,720,100	21
Inter-Fund Transfers.....	10,006,900	15	4,462,400	7	96,500	1	17,477,400	5
Total	$67,774,300	100	$64,683,300	100	$8,593,000	100	$317,642,400	100

[a] For the purposes of this analysis public works includes all services related to sanitation, transportation, and water systems.

[b] Subsidies include expenditures for water and sewer utilities, mass transit, and solid waste management.

[c] Enterprises include expenditures for airports, parking, sewer and water utilities, mass transit, and solid waste management.

[d] Capital projects include expenditures for street and highway construction/reconstruction, highway, buildings and equipment, storm sewers, and sanitation.

[e] Special assessments include expenditures for streets, sidewalks, curbs and gutters, storm sewers, and sanitary sewers.

Source: Wisconsin Department of Administration and SEWRPC.

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Table IV.3

STREET AND ALLEY SWEEPING COSTS FOR THE CITY OF MILWAUKEE, WISCONSIN: 1976-1980

Street Sweeping

Year	Hours Worked	Miles Swept	Cubic Yards of Sweepings	Total Cost	Cost per Hour	Cost per Cubic Yard	Cost per Curb Mile
1976	20,358	46,855	48,155	$ 477,999	$23.48	$ 9.93	$10.20
1977	20,234	47,069	33,746	500,776	24.75	14.84	10.64
1978	22,335	57,330	52,775	848,730	38.00	16.08	14.80
1979	21,741	56,455	52,033	835,724	38.44	16.06	14.80
1980	24,228	62,810	54,229	1,015,800	41.93	18.73	16.17

Alley Sweeping

Year	Hours Worked	Miles Swept	Cubic Yards of Sweepings	Total Cost	Cost per Hour	Cost per Cubic Yard	Cost per Alley Mile
1976	4,464	10,444	7,649	$ 104,803	$23.48	$13.70	$10.03
1977	4,412	11,214	5,924	110,990	25.16	18.74	9.90
1978	3,435	9,668	4,116	130,530	38.00	31.71	13.50
1979	2,629	7,302	3,790	101,059	38.44	26.66	13.84
1980	2,756	7,157	4,192	122,297	44.37	29.17	17.09

Total Sweeping

Year	Hours Worked	Miles Swept	Cubic Yards of Sweepings	Total Cost	Cost per Hour	Cost per Cubic Yard	Cost per Curb or Alley Mile
1976	24,822	57,299	55,804	$ 582,802	$23.48	$10.44	$10.17
1977	24,646	58,283	39,670	611,766	24.82	15.42	10.50
1978	25,770	66,998	56,891	979,260	38.00	17.21	14.62
1979	24,370	63,757	55,823	936,783	38.44	16.78	14.69
1980	26,984	69,967	58,421	1,138,097	42.18	19.48	16.27

Source: City of Milwaukee and SEWRPC.

Table IV.4

DISTRIBUTION OF COSTS AND UNIT COSTS FOR STREET SWEEPING PROGRAMS

	Nationwide Urban Runoff Program (NURP) Studies							
Cost Factor	Milwaukee, WI	Winston Salem/ Forsych County, N.C.	San Francisco Bay Area, CA	Champaign, IL	San Jose, CA (Pitt, 1979)	1975 SEWRPC Survey of Street Cleaning Practices[a]	1978 Local Units of Government in Southeastern Wisconsin[b]	Mean of All Studies[c]
Cost Distribution(%)								
Wages and Salaries	34	28	40	50	59	36	33	40
Indirect Labor, Fringe Benefits, and Overhead	9[d]	5	16	10	15[d]	9[d]	8[d]	10
Maintenance and Materials	14	33	21	25	11	37	56	28
Fuel	11	12	7[d]	5	4[d]	12[d]	3	8
Equipment Depreciation	16	19	5	NA	3	NA	NA	6
Disposal	16	3	11	10	8	6	NA	8
Total	100	100	100	100	100	100	100	100
Unit Costs($)								
Cost per Pound of Solids Collected	NA	0.13-0.72	0.09-0.26	NA	0.039-0.25	0.025	NA	0.19
Cost per Cubic Yard of Solids Collected	NA	NA	NA	NA	31.00[e]	NA	21.52[f]	26.26
Cost per Curb-Mile Swept	19.33	13.81	10.00-15.00	11.03-13.94	21.00	NA	17.98[f]	16.18
Cost per Hour of Sweeping Operation	27.87	16.89-36.02	NA	NA	23.00	NA	46.60[f]	30.98

NA - Not Available
Note: All costs are in 1981 dollars.

[a] 1975 street cleaning practices by towns, villages, cities, and counties in southeastern Wisconsin were surveyed by the Southeastern Wisconsin Regional Planning Commission under its areawide water quality management (208) program. The survey results were not published but are available in the Commission files.

[b] 1978 Public Works expenditures by local units of government in southeastern Wisconsin as reported to the Wisconsin Department of Administration.

[c] Where cost distribution data were not available, a value of zero was used to calculate the mean. Where ranges were given for unit costs, the mean of the high and low value were used to calculate study means.

[d] Costs for these categories were included in other categories in the respective studies. The values shown herein were estimated by distributing the costs by the same proportion as was reported by those studies which did include these categories.

[e] Median of 400 cities surveyed by APWA (1975).

[f] Reported for 1980 by the City of Milwaukee, Wisconsin.

Source: SEWRPC

pound of solids collected ranged from $0.025 to $0.72, with a mean of $0.19. Costs per cubic yard of solids collected ranged from $21.52 to $31.00, with a mean of $26.26. Costs per curb mile swept ranged from $10.00 to $21.00, with a mean of $16.18. Costs per hour of sweeping operation ranged from $16.89 to $46.60, with a mean of $30.98. Of the above unit costs, the costs per curb mile swept are probably the most reliable because of the relative reliability with which the curb miles swept can be measured. Accordingly, unit costs per curb mile swept are used in Chapter V of this volume to determine the costs of different frequencies of street sweeping and to evaluate the cost-effectiveness of street sweeping.

DETENTION AND RETENTION BASINS

The practice of detaining or retaining stormwater runoff from urban areas to mitigate the effects of flooding, pollutant contributions, soil erosion, and downstream sedimentation, as well as to reduce the capital costs of downstream drainage facilities, is now recognized and accepted as a viable and sound stormwater management alternative. To evaluate stormwater storage as an alternative water quality management measure in urban areas, this section evaluates the costs of surface modified detention basins and retention basins. Costs are also estimated for installing modifications to detention basins to improve their pollutant removal effectiveness, as discussed in Chapter III.

Local agencies and private land developers and other private entities responsible for the construction, operation and maintenance of modified detention basins and retention basins may encounter costs for administration, planning, and land acquisition, as well as construction, and operation and maintenance. Administration and planning costs for modified detention basins and retention basins include costs for plan preparation and plan review, enforcement of related regulations and ordinances, inspection, engineering, and clerical support. When performed by public agencies, such activities may be considered part of normal government operation. Administration and planning costs for modified detention basins and retention basins may be expected to be similar to, or slightly higher than, such costs for other stormwater management facilities.

Land acquisition costs may be high for modified detention basins and retention basins, particularly when corrective measures are being undertaken in existing developed urban areas. Such costs may be minimized when the basins can be designed for multiple uses, such as joint use as a park or parkway. Even in established urban areas, basins can sometimes be located on existing public land. In newly developing areas, land acquisition costs may be lowered by utilizing land unsuitable for urban development without expensive grading or filling. Costs may also be mitigated by the increased land values expected adjacent to a properly maintained open space or water feature.

Construction costs of basins are determined by the type of facility, location, size, land suitability, soil conditions, cost of labor, cost of materials, and engineering costs. Construction costs include expenditures for excavation and grading, erosion control measures, fencing and other security measures, inlets and outlets, pumping facilities, landscaping, modifications needed to provide multiple-use benefits or to maximize the pollutant removal efficiency, and engineering and financing.

Planned and continual operation and maintenance of modified detention basins and retention basins help sustain the aesthetic values, hydraulic effectiveness, and pollutant removal efficiency of the basins. Historically, the planning and design of existing detention and retention basins has often failed to give adequate consideration to maintenance of the basins, and excessive sedimentation and vegetation growth has resulted in some cases, impairing the appearance and effectivenss of the basins (Kamedulski and McCuen, 1979). In general, operation and maintenance costs are seldom recorded or documented, the costs are highly variable from basin to basin and from year to year, and many operation and maintenance activities which are conducted are performed only on an as-needed basis. Nevertheless, the proper utilization of either modified detention basins or retention basins as water quality management measures requires that costs be estimated for operation and maintenance, and that these costs be included in any preliminary plans and alternative analyses which address such basins. Costs for the operation and maintenance of modified detention basins and retention basins should consider expenditures for mosquito control, algae and aquatic weed control, water pollution problems, debris removal, erosion control, sediment removal and disposal, maintenance of safety features, maintenance of inlets and outlets, landscape maintenance, litter control, structural maintenance, and maintenance of access facilities.

To help evaluate the cost-effectiveness of modified detention basins at the systems planning level and to help evaluate the feasibility of providing these basins as alternative water quality management measures, the capital cost curve shown in Figure IV.1 is provided. The capital costs are related to the design storage capacity, in acre-feet, of the modified detention basin. The curve presents costs for basins with storage capacities of from 1,000 to 1.0 million cubic feet, an appropriate size range for urban or urbanizing areas.

The capital cost curve for modified detention basins is derived from a base construction cost relationship developed by the Metropolitan Washington Council of Governments (1983) under its NURP study. The base construction cost is represented by the following formula:

$$\text{Base Construction Cost} = 77.4 \quad V^{0.51}$$

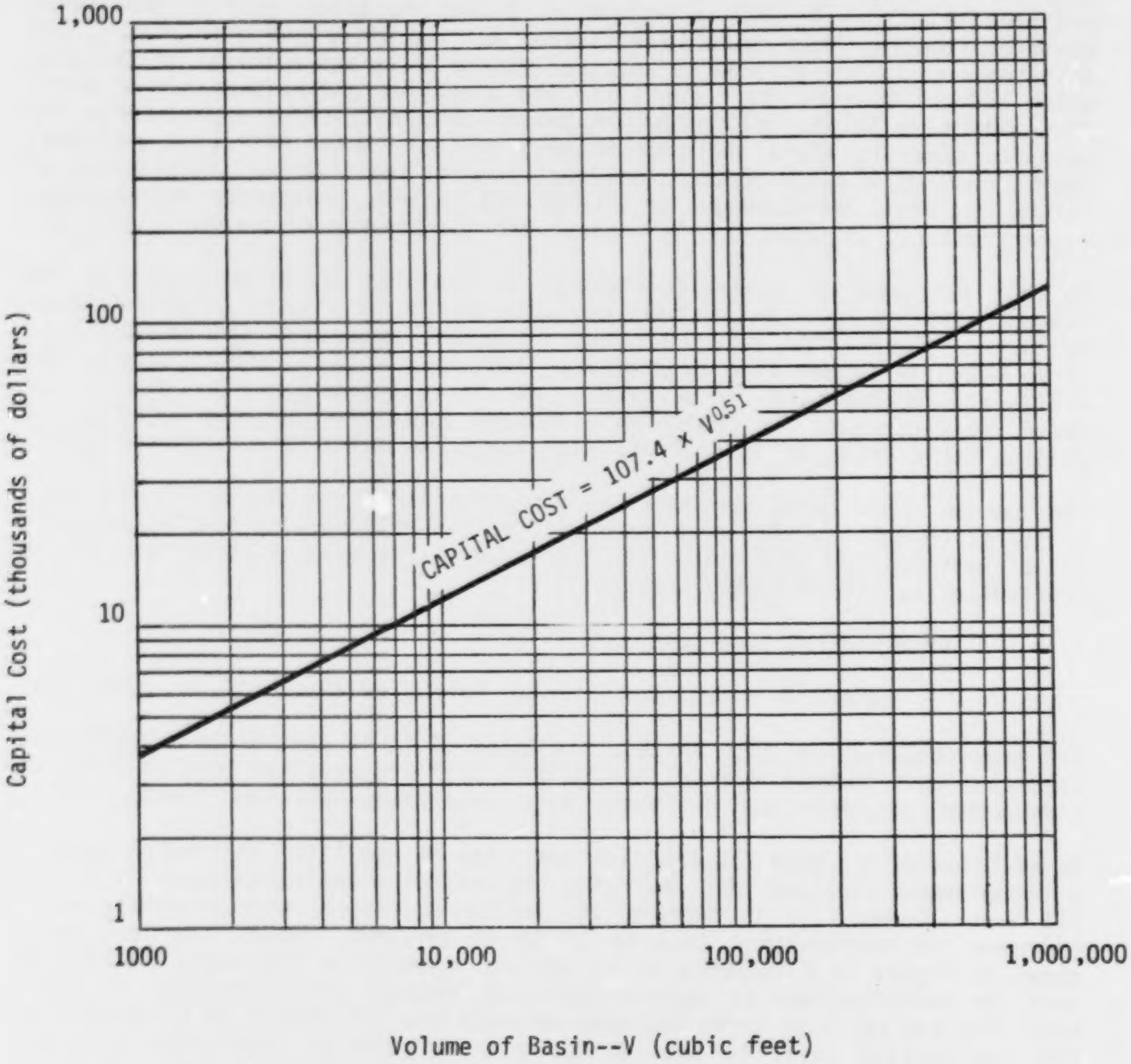
Where V = designed storage volume of the basin in cubic feet

The base construction cost formula presented above is similar to a basin construction cost formula derived by the U.S. Soil Conservation Service using an independent approach and different data base (Detullio and Thomas, 1977).

In addition to the base construction cost, the Metropolitan Washington Council of Governments reported that modifying the detention basin, as shown in Figure III.3 in Chapter III, to improve its pollutant removal effectiveness, would increase its construction cost by 10 to 12 percent. Hence, the cost curve shown in Figure IV.1 includes an 11 percent increase in the base construction cost for modifications to improve pollutant removal effectiveness. In addition, the capital cost curve includes an additional allowance of 25 percent of the construction cost, to provide for planning, design, administration, and other construction-related contingencies. Thus, the total capital cost curve for modified detention basins shown in Figure IV.1, consisting of a base construction cost, an 11 percent increase for modifications, and a 25 percent

Figure IV.1

CAPITAL COST CURVE FOR MODIFIED DETENTION BASINS



NOTE: Capital costs are in January 1981 dollars. Capital costs include construction, modifications to improve the pollutant removal effectiveness of the basin, planning, design, administration, and other construction-related contingencies. Land acquisition costs are not included in the above capital costs.

Source: Metropolitan Washington Council of Governments (19830 and SEWRPC.

increase for related costs, is represented by the following formula:

$$\text{Capital Cost} = 107.4 \times V^{0.51}$$

For retention basins, additional capacity must be provided for the permanent pool. Hence, the capital cost for a retention basin is significantly higher than the capital cost of a modified detention basin with the same incremental storage capacity. However, modifications would generally not be required for retention basins, and an analysis of the cost curve shown in Figure IV.1 indicates that the capital cost per unit volume of storage decreases as the total basin volume increases. In general, a retention basin with one half of the basin volume filled by a permanent pool, would cost about 30 percent more than a modified detention basin having the same incremental storage volume.

However, this higher cost for a retention basin may be justified for purposes other than water quality protection. Retention basins may provide desired aesthetic and recreational benefits, improving the value of property adjacent to the basin. Furthermore, the additional costs required to provide a permanent pool may be offset later by reducing the required frequency of sediment removal as part of the basin operation and maintenance. Sediment stored in the permanent pool reduces the depth of the pool but does not reduce the incremental storage capacity of the basin.

Because permanent pool volumes may vary widely in relation to the storage capacities and because other benefits may justify the increased cost of retention basins, the cost curve shown in Figure IV.1 developed for modified detention basins, was used in the alternative analyses presented in Chapter V. It is recognized that, at some basin sites, retention basins may be more appropriate for a variety of reasons. However, the approximate 30 percent increase in cost required to construct a retention basins instead of a modified detention basin is assumed to be offset by other benefits provided by a retention facility, such as aesthetics and recreational uses.

Specific operation and maintenance activities for stormwater storage basins may include grass maintenance, debris and litter removal, bank stabilization, weed control, insect control, algae control, fence repair, structural repairs and replacement, sediment and debris removal, and basin administration and management. The operation and maintenance costs presented below are based on routine maintenance, one inspection of the basin each year, sediment and debris removal once every five years, and major repair as required.

The Metropolitan Washington Council of Governments (1983) study reported that routine operation and maintenance costs represent approximately 2 to 3 percent of the average capital costs. Sediment and debris removal and other nonroutine activities were estimated to cost from 1 to 2 percent of the capital cost on an annual basis. Thus, combining all maintenance costs, from 3 to 5 percent of the capital cost can be used to project annual operation and maintenance costs for stormwater storage basins. A value of 5 percent was used to estimate basin operation and maintenance costs in the alternative analyses set forth in Chapter V.

CATCH BASINS

Capital costs for material and labor to install catch basins generally range from $900 to $1,400 per basin (Robert Snow Means Co., Inc., 1982). The City of Milwaukee reports similar costs. Cleaning costs for catch basins have been estimated in two NURP studies (Midwest Research Institute, 1982). In the Castro Valley, California NURP study, a cleaning cost of $6 per basin cleaned, or about $0.10 per pound of solids removed, was reported. In the Salt Lake County, Utah NURP study, a cost of $8 per basin cleaned was reported. Basins in both NURP studies were cleaned with a vacuum attachment to a street sweeper. Data from the City of Milwaukee, Wisconsin indicated a catch basin cleaning cost with a vacuum attachment of about $0.05 per pound of solids removed (SEWRPC, 1977). SEWRPC Technical Report No. 18 (1976) reported that cleaning catch basins manually by hand or with a clamshell bucket costs about twice as much as cleaning the basins with a vacuum attachment to a sweeper. However, because catch basins are not being used as components of many new urban storm sewer systems, and because the water quality benefits of catch basin cleaning are highly variable and cannot be accurately quantified, catch basin installation and cleaning costs were not specifically included in the alternative analyses set forth in Chapter V.

CHAPTER V

EVALUATION OF ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR SELECT URBAN AREAS OF SOUTHEASTERN WISCONSIN

INTRODUCTION

This chapter presents an evaluation of the costs and the level of pollutant loading reduction which may be expected if alternative nonpoint source control measures are implemented in selected urban areas of southeastern Wisconsin. In particular, this chapter applies the cost and pollutant removal estimating procedures described previously in Volume One and in this volume of the report to three study watersheds. The purpose of this chapter is to demonstrate, at a systems planning level, for specific urban areas what the cost of urban nonpoint source control would likely be, what level of pollutant loading reduction could be achieved by the implementation of these urban nonpoint source control measures, and what the cost effectiveness is of the nonpoint source control measures.

It is important to note that this chapter does not present a recommended plan for the control of urban nonpoint sources for the study watersheds. The preparation of an urban nonpoint source control plan is properly the responsibility of the local units of government concerned in cooperation with state and regional agencies, upon careful consideration of the economic, social, political, legal, and environmental aspects of the alternative control measures. Such a detailed and comprehensive analysis of alternative nonpoint source control measures has not been conducted for the study watersheds, nor have the local units of government concerned been directly involved in the preparation or evaluation of the alternative measures. This chapter sets forth the costs and pollutant removal levels which may be expected if certain nonpoint source control measures were implemented in the study watersheds.

The urban nonpoint source control measures specifically evaluated in this chapter are street sweeping and modified detention and retention basins. Each alternative is evaluated under existing land use conditions so that the direct impacts of the nonpoint source control measures can be compared to the impacts of the existing land management practices. All costs and pollutant removal levels represent incremental costs and removal levels compared to existing conditions.

Improved street sweeping programs are considered for evaluation only for those municipalities which currently conduct street sweeping; new street sweeping programs for municipalities which currently do not conduct street sweeping were not evaluated. Within each study watershed existing pollutant loadings, as well as the sources of these loadings, were quantified using the Wisconsin Urban Runoff Model (WURM), described in Volume III of this report. The increased level of pollutant removal expected to be achieved by improved street sweeping programs was evaluated with the use of the Street Load and Washoff (SLAW) model results, which were presented in Volume I and in Volume III. The cost of street sweeping programs was estimated by applying a unit cost of $16 per curb mile swept, as discussed in Chapter IV. The entire incremental cost for improved street sweeping was assumed to be for operation and maintenance, since the municipalities already had established street sweeping programs, and it was assumed that the municipalities would not need to purchase additional sweepers. Depreciation of equipment was included in the operation and maintenance cost.

Modified detention basins and retention basins were evaluated where sufficient open land area on a surface water drainageway existed to accommodate a basin, and where the tributary drainage area to the basin was generally urbanized and of appropriate size--generally 200 to 1,000 acres--to drain to a one- to five-acre basin. Pollutant loadings to the basins were estimated with the WURM model. The pollutant removal effectiveness of modified detention basins and retention basins were estimated by the application of the removal curves for various pollutants set forth in Figure III.4 in Chapter III. The capital costs of the basins were estimated with the capital cost curve presented in Figure IV.1 in Chapter IV. Annual operation and maintenance costs for the basins were assumed to equal 5 percent of the capital cost.

The cost analysis provides an important basis for the evaluation of the economic aspects of the alternative plans considered. To compare the costs of the alternatives, a present-worth analysis was conducted. The present worth, which converts future expenditures to a present value, was calculated by using a 7 5/8 percent interest rate, as recommended by current U. S. Environmental Protection Agency guidelines, and a 20-year economic analysis period. It was assumed that the stormwater storage basins would have an approximate 20-year economic life. A capital recovery factor was then applied to convert the total present worth of an alternative into a series of uniform annual costs over the length of the economic analysis period. This uniform annual cost is referred to as the equivalent annual cost.

Pollutant removal levels were estimated for total solids, volatile suspended solids--a measure of the amount of organic substances, total nitrogen, total phosphorus, and total lead. All pollutant loadings were expressed in terms of annual loadings, although no loadings are assumed during the months of December, January, and February because of snow and ice conditions.

The three urban study watersheds evaluated in this chapter are drained by Noyes Creek, the Upper Root River, and Lincoln Creek. The Noyes Creek watershed is 1,360 acres in size and drains primarily medium-density residential land uses. Substantial amounts of parkland and open land also exist in the Noyes Creek watershed, which is tributary to the Little Menomonee River. The Upper Root River watershed, as delineated in this report, drains approximately 10,300 acres of residential and mixed land uses. The Upper Root River watershed is a rapidly urbanizing watershed with a large amount of open space present. The third study watershed, drained by Lincoln Creek, a tributary to the Milwaukee River, is about 12,900 acres in size. The Lincoln Creek watershed drains primarily high-density residential land, although the headwaters drain some open land areas.

For each of the three study watersheds, this chapter presents a description of pertinent natural resources and man-made features, and a discussion of existing water quality conditions and nonpoint source pollution control recommendations set forth in the regional water quality management plan for southeastern Wisconsin. Alternative street sweeping programs are described, as is the potential use of modified detention basins or retention basins. These alternative nonpoint source control measures are evaluated with respect to cost and pollutant removal effectiveness. A cost effectiveness analysis is also presented for each watershed.

NOYES CREEK WATERSHED

Description

The Noyes Creek watershed is a 1,363-acre surface water drainage basin located entirely within the City of Milwaukee. The overall length of the main stem of Noyes Creek, which is an intermittent stream, is approximately 2.5 miles from its source to its confluence with the Little Menomonee River. A smaller, intermittent tributary approximately 1.1 miles in length drains the southern portion of the watershed and empties into the main stem of Noyes Creek about 0.6 mile upstream of its confluence with the Little Menomonee River. For analysis purposes, the watershed was divided into four subbasins, as shown on Map V.1.

The soils and topography in the Noyes Creek watershed have been altered by grading, excavation, and filling as a consequence of the urbanization which has occurred. The three most common soils, in order of predominance, are Ozaukee silt loam, Mequon silt loam, and Ashkum silt loam. The Ozaukee and Mequon soils are located primarily throughout the upland portions of the watershed, while the Askhum soil is found predominantly adjacent to the surface water drainageways. These three soils generally have slow infiltration rates and are poorly drained. Consequently, they have a potential for producing higher levels of stormwater runoff and associated nonpoint source pollutant loadings compared to better drained soils. The land surface slopes in the watershed range from nearly level up to a maximum of 9 percent, with an average land surface slope of about 3 percent.

As shown in Table V.1 and on Map V.1, urban land uses cover approximately 1,133 acres, or 83 percent of the watershed. The predominant urban land uses are medium-density residential use and transportation uses, which encompass 434 acres, or 32 percent, and 240 acres, or 18 percent of the watershed, respectively. Rural land uses cover approximately 230 acres, or 17 percent of the watershed. The predominant rural land use is open land, which encompasses 200 acres, or about 15 percent of the watershed.

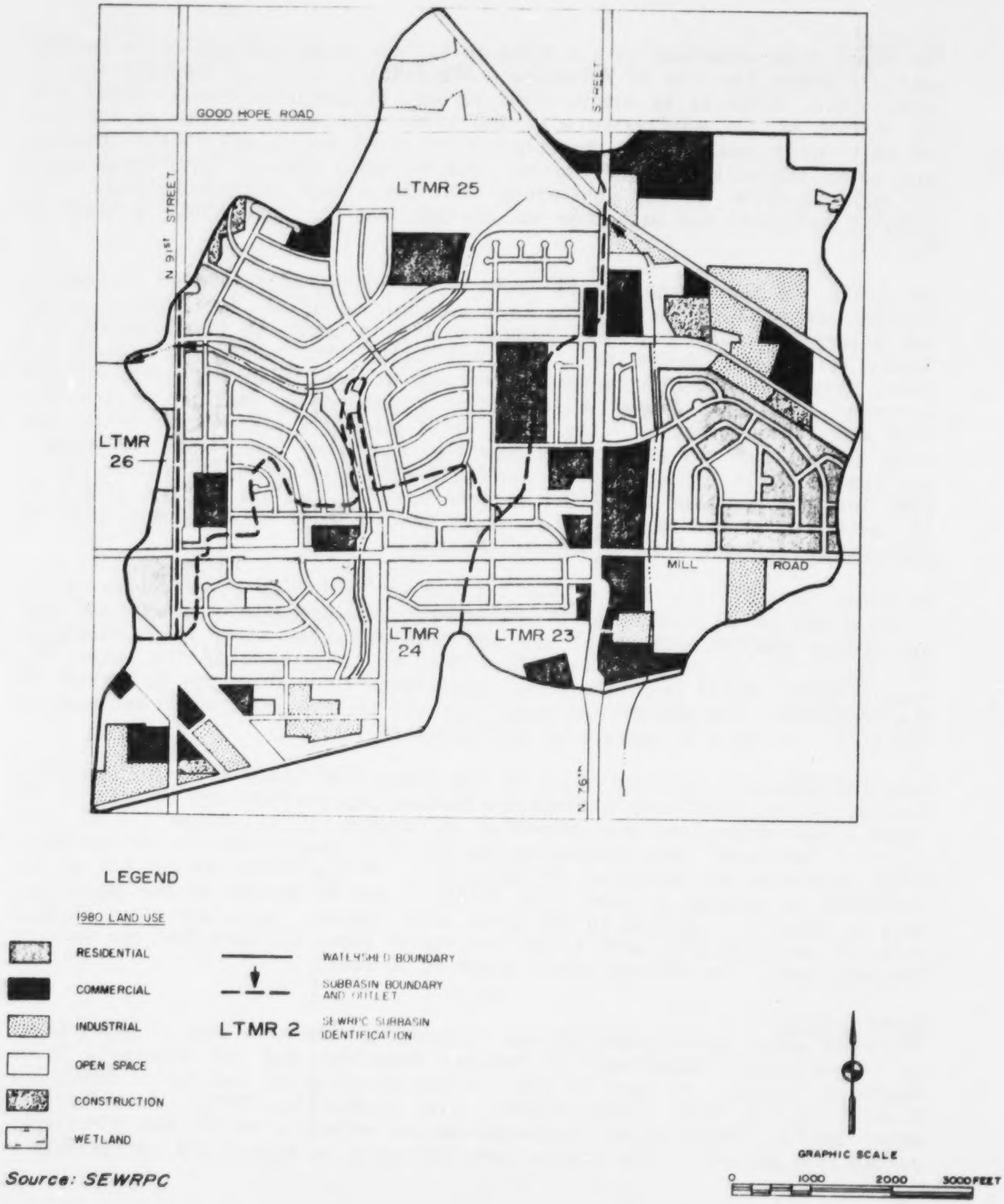
Detailed physical characteristics of the eight NURP study sites in Milwaukee County, two of which--the Hastings and Burbank study sites--are located in the Noyes Creek watershed, are presented in Chapter II of Volume III of this report. Additional data concerning the physical characteristics of the Noyes Creek watershed are presented in Table V.2. Approximately 44 percent of the watershed is covered by impervious surfaces, and 82 percent of the impervious area is directly connected to the storm sewer system. There are about 55 curb miles of paved streets, with a curb density of about 213 curb feet per acre in the watershed. The average street width is 30 feet.

Water Quality

Extensive water quality sampling was conducted on the main stem of Noyes Creek by the Wisconsin Department of Natural Resources and the Wisconsin Water Resources Center, as part of the International Joint Commission Menomonee River Watershed Study (International Joint Commission, 1979). Specifically, water quality sampling was conducted during rainfall events and non-events during 1976 and 1977. The samples were collected on Noyes Creek approximately

Map V.1

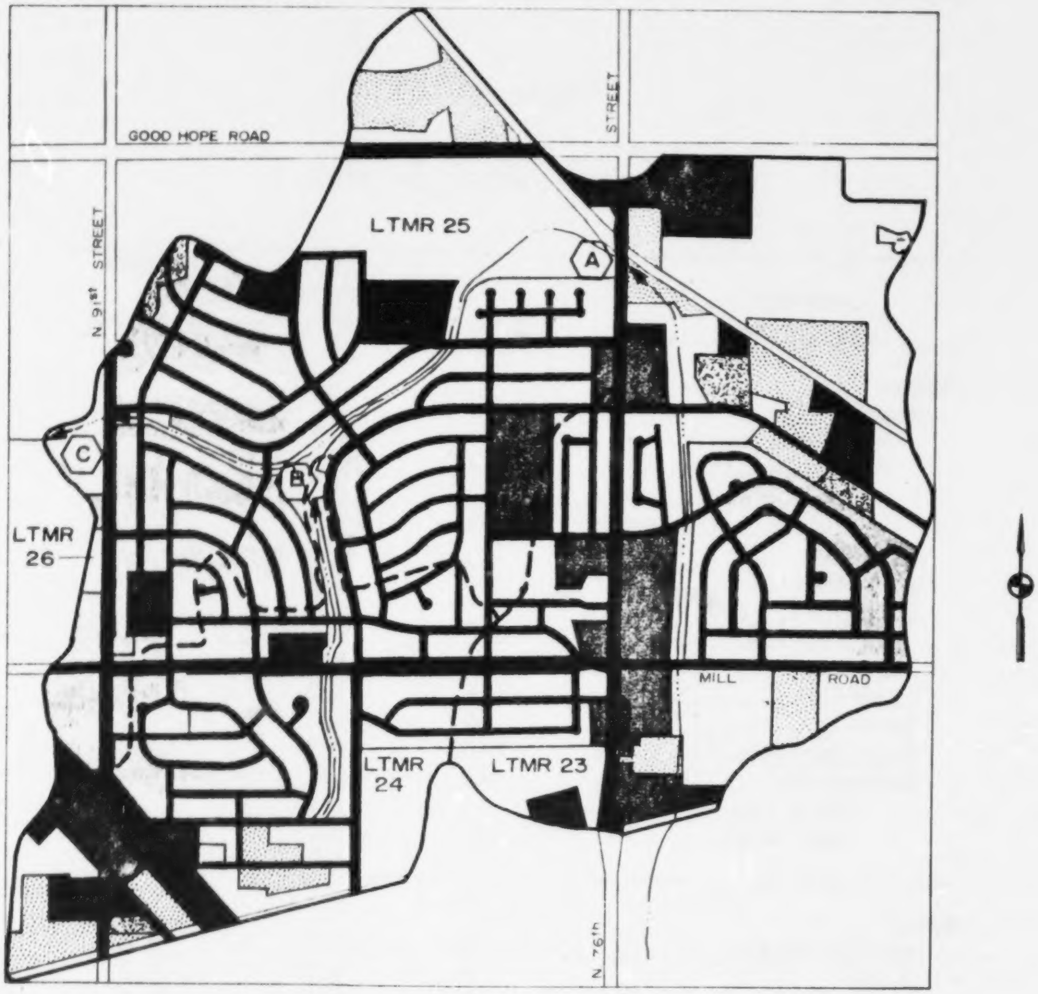
EXISTING LAND USE IN THE NOYES CREEK WATERSHED: 1980



Source: SEWRPC

Map V.2

ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR THE NOYES CREEK WATERSHED



LEGEND

1980 LAND USE

■	RESIDENTIAL	—	WATERSHED BOUNDARY
■	COMMERCIAL	—↓—	SUBBASIN BOUNDARY AND OUTLET
▨	INDUSTRIAL	LTMR 2	SEWRPC SUBBASIN IDENTIFICATION
☐	OPEN SPACE	▬	STREETS SWEPT
▨	CONSTRUCTION	Ⓐ	STORMWATER STORAGE BASIN DESIGNATION
▤	WETLAND		

Source: SEWRPC

ALTERNATIVE DESCRIPTION

ALTERNATIVE	INCREASED STREET SWEEPING	STORMWATER STORAGE
IMPROVED STREET SWEEPING PROGRAM I	SPRING AND FALL ONLY	NONE
IMPROVED STREET SWEEPING PROGRAM II	ENTIRE SWEEPING SEASON	NONE
STORMWATER STORAGE I	NONE	BASINS A AND B
STORMWATER STORAGE II	NONE	BASIN C
COMBINATION	SPRING AND FALL ONLY	BASIN C

GRAPHIC SCALE

0 1000 2000 3000 FEET

Table V.1

EXISTING LAND USE IN THE
NOYES CREEK WATERSHED: 1980

Land Use Categories	Acres	Percent of Major Category	Percent of Watershed
Urban			
Residential			
High Density	74	6.5	5.4
Medium Density	434	38.3	31.8
Low Density	11	1.0	0.8
Residential Subtotal	519	45.8	38.0
Construction	12	1.1	0.9
Commercial, Utilities, and Institutional	112	9.9	8.2
Industrial	64	5.7	4.7
Landfill	14	1.2	1.0
Parking	65	5.7	4.8
Transportation	240	21.2	17.6
Recreation	107	9.4	7.9
Urban Land Use Total	1,133	100.0	83.1
Rural			
Agricultural	8	3.5	0.6
Water	3	1.3	0.2
Wetlands	2	0.9	0.1
Woodlands	17	7.4	1.3
Other Open Lands	200	86.9	14.7
Rural Land Use Total	230	100.0	16.9
Total	1,363	--	100.0

Source: SEWRPC.

Table V.2

SELECTED PHYSICAL CHARACTERISTICS OF THE NOYES CREEK WATERSHED: 1980

Subbasin[a]	Areal Extent (acres)	Percent Impervious	Percent Impervious Directly Connected to Storm Sewer System	Street Width (feet)	Curb Length (miles)	Curb Density (feet/acre)
LTMR-23	542	44	85	30	17.4	169.1
LTMR-24	289	45	82	30	16.1	295.0
LTMR-25	506	43	78	30	20.4	213.3
LTMR-26	26	30	84	30	1.0	205.7
Total	1,363	44	82	30	54.9	212.9

[a] Denotes SEWRPC-delineated subbasin numbers in the Little Menomonee River watershed.

Source: SEWRPC.

0.25 mile upstream of its confluence with the Little Menomonee River. Measured stream flows and selected water quality data are presented in Table IV.3. Spring, summer, and fall stormwater flows and pollutant concentrations were evaluated.

The data indicate, as shown in Table V.3, that concentrations of most pollutants in stormwater runoff are higher in spring than in summer or fall. The mean concentrations of total solids, suspended solids, volatile suspended solids, ammonia nitrogen, and chloride were highest in spring and lowest in fall. Concentrations of soluble and total phosphorus and zinc were about the same during spring as they were in summer. Concentrations of lead were highest during the summer.

In Noyes Creek, the adopted water use objectives set forth in the regional water quality management plan consist of maintenance of a warmwater fishery and associated aquatic life and limited recreational use (SEWRPC, 1979). The suitability of the observed water quality conditions for supporting the adopted water use objectives may be determined by comparing the measured water quality data to water quality standards. Of the water quality parameters shown in Table V.3, water quality standards have been established by the Wisconsin Department of Natural Resources (DNR) for un-ionized ammonia nitrogen, lead, and zinc. In addition, the adopted regional water quality management plan for southeastern Wisconsin recommended a water quality standard for un-ionized ammonia nitrogen which was more stringent than the DNR standard (SEWRPC, 1979). The un-ionized ammonia nitrogen concentration is dependent upon the concentration of total ammonia nitrogen, by the pH, and by the temperature of the water. Neither the DNR standard for un-ionized ammonia nitrogen of a maximum of 0.04 mg/l nor the SEWRPC standard of a maximum of 0.02 mg/l to support warmwater fish and aquatic life are exceeded in Noyes Creek. Lead and zinc criteria, as proposed by the U.S.EPA (Federal Register, Vol. 45, No. 231, November 28, 1980) and established as standards by the DNR, are based on the hardness of the water and are presented for short-term (acute) effects, and long-term (chronic) effects. In Noyes Creek, the mean measured levels of both lead and zinc were over twice the chronic standards of 0.019 mg/l for lead and of 0.047 mg/l for zinc during spring and summer. The acute standard of 0.28 mg/l for lead was exceeded by the maximum level measured during summer. These excessive concentrations of metals may be harmful to desired fish and other aquatic organisms. In addition to the above-noted violations of the lead and zinc standards, it is also likely, based on experiences with other urbanized watersheds, that the fecal coliform standard to support recreational uses is occasionally violated in the watershed, although no fecal coliform data were available for comparison to the standard for fecal coliform.

Nonpoint sources of pollution contribute virtually all of the pollutants transported to surface waters in the watershed. A minimum level of nonpoint source pollution control was recommended in the adopted regional water quality management plan for the Noyes Creek watershed. Urban practices recommended to be considered to achieve the minimum level of control include improved urban "housekeeping" practices such as improved timing and efficiency of street sweeping, leaf and vegetative debris collection, and catch basin cleaning; construction site erosion control; pet waste and litter control; and the conduct of public education programs to inform property owners as to the importance of proper use and disposal of fertilizers and household chemicals to improve water quality.

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Table V.3

SEASONAL AVERAGES AND RANGES OF STREAMFLOW AND CONCENTRATIONS OF SELECTED WATER QUALITY PARAMETERS IN NOYES CREEK: 1976-1977[a, b]

Parameter	Spring			Summer			Fall			Total		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minumum	Mean	Maximum	Minimum
Flow (cubic meter per second)........	0.64	6.09	0.06	0.36	7.65	0.00	0.14	0.71	0.11	0.48	7.65	0.00
Total Solids........	871.3	2,958.0	4.00	474.2	3,580.0	180.0	272.9	400.0	185.0	661.8	3,580.0	4.0
Suspended Solids....	173.6	3,620.0	8.0	135.1	2,976.0	1.0	30.4	64.0	12.0	153.5	2,976.0	1.0
Volatile Suspended Solids...	19.8	170.0	2.0	18.4	144.0	1.0	10.5	17.0	6.0	19.0	170.0	1.0
Total Phosphorus....	0.22	1.5	0.03	0.22	1.48	0.01	0.13	0.38	0.70	0.21	1.5	0.01
Soluble Phosphorus..	0.03	0.29	0.0	0.04	0.78	0.0	0.02	0.09	0.0	0.04	0.78	0.0
Ammonia Nitrogen....	0.25	0.79	0.03	0.17	2.00	0.01	0.05	0.14	0.02	0.19	2.0	0.01
Chloride............	232.0	1,050.0	30.0	56.2	160.0	8.0	27.8	64.0	12.0	141.1	1,050.0	8.0
Lead................	0.05	0.24	0.01	0.11	0.76	0.0	--	--	--	0.09	0.76	0.0
Zinc................	0.11	0.39	0.03	0.10	0.49	0.01	--	--	--	0.11	0.49	0.01

[a] Sampling station located on Noyes Creek approximately 0.25 mile upstream of its confluence with the Little Menomonee River.

[b] All parameters expressed in milligrams per liter (mg/l) except as noted.

Source: The International Joint Commission and SEWRPC.

Description of Alternative Nonpoint Source Control Measures

This section describes the street sweeping programs and the use of modified detention basins or retention basins as alternative nonpoint source control measures for the Noyes Creek watershed. Two improved street sweeping program alternatives were developed. Two alternatives were also developed which included the use of stormwater storage facilities--modified detention basins or retention basins--where appropriate, along with the existing street sweeping program. Finally, an alternative was developed which included a stormwater storage facility used in combination with an improved street sweeping program. The specific nonpoint source control measures, street sweeping program, and location, size, and drainage area of any modified detention basins or retention basins assumed for each alternative are set forth in Table V.4.

Existing pollutant loadings are estimated in order to provide baseline conditions. Within the Noyes Creek watershed, all of the streets are currently swept an average of once per month approximately from March through November. The streets which are swept are illustrated on Map V.2.

Two improved street sweeping alternatives are evaluated. The "Improved Street Sweeping Program I" alternative, as shown on Map V.2, includes an intensive street-sweeping effort in early spring--sweeping all streets an additional three times in March--to reduce high spring street surface loadings prior to the onset of heavy spring rainstorms. In addition, street sweeping would be intensified--sweeping at a frequency of once per week--during October to reduce high fall loadings, including leaves and other vegetative debris. During the remainder of the sweeping season--from March through November--all streets would be swept at the existing frequency--once per month. The second improved street sweeping alternative, "Improved Street Sweeping Program II", also includes the intensive sweeping efforts in spring and in fall. However, this second alternative also includes sweeping all streets shown on Map V.2 at an increased frequency--twice per month, during the remainder of the sweeping season. Both of the improved street sweeping alternatives assume that sweeping operations would be properly and efficiently conducted in accordance with the methods set forth in Table III.3 of Chapter III.

Two stormwater storage alternatives are also evaluated for the Noyes Creek watershed. The "Stormwater Storage I" alternative would involve the use of two modified detention basins or retention basins, each ranging in size from one to two acres, to temporarily store urban stormwater runoff from a total of about 830 acres, or about 61 percent of the entire Noyes Creek watershed. Map V.2 shows the location of the two basins evaluated for this alternative. The "Stormwater Storage II" alternative would include a single modified detention basin or retention basin--five acres in size--to store urban stormwater runoff from the entire 1,363-acre Noyes Creek watershed. Map V.2 also shows the location of this single stormwater storage facility. Both the "Stormwater Storage I" and "Stormwater Storage II" alternatives include the existing street sweeping program. A "Combination" alternative was also developed and includes the single stormwater storage facility used in "Stormwater Storage II" in combination with the "Improved Street Sweeping Program I" alternative.

Evaluation of Alternatives

An evaluation of the pollutant removal effectiveness, cost, and cost effectiveness of the alternative nonpoint source control measures is presented below. It is recognized, however, that management decisions cannot be based

Table V.4

DESCRIPTION OF NONPOINT SOURCE CONTROL ALTERNATIVES FOR THE NOYES CREEK WATERSHED

		Modified Detention Basins or Retention Basins		
Alternative	Street Sweeping Frequency	Location (Subbasin)	Basin Area (Acres)	Tributary Drainage Area (Acres)
Existing Street Sweeping Program	Sweep all streets once per month from March through November.	None	None	None
Improved Street Sweeping Program I	Sweep all streets an additional 3 times in March; sweep all streets an additional 3 times in October; sweep all streets once per month for the remainder of the sweeping season.	None	None	None
Improved Street Sweeping Program II	Sweep all streets an additional 3 times in March; sweep all streets an additional 3 times in October; sweep all streets twice per month for the remainder of the sweeping season.	None	None	None
Stormwater Storage I	Sweep all streets once per month from March through November.	Basin A - LTMR 24	1	289
		Basin B - LTMR 25	2	542
Stormwater Storage II	Sweep all streets once per month from March through November.	Basin C - LTMR 26	5	1,363
Combination Stormwater Storage II and Improved Street Sweeping Program I	Sweep all streets an additional 3 times in March; sweep all streets an additional 3 times in October; sweep streets once per month for the remainder of the sweeping season.	Basin C - LTMR 26	5	1,363

Source: SEWRPC.

entirely on water quality impacts, but that other factors which must be addressed by local governmental agencies also influence decision making. These factors include economics, political and public acceptance, skills and resources, maintenance requirements, management considerations, and safety and nuisance factors.

Pollutant Removal: Pollutant removal levels expected to be achieved by each of the alternative nonpoint source control measures evaluated for the Noyes Creek watershed are set forth in Table V.5. The table indicates that there is little significant difference between the Improved Street Sweeping Program I alternative and the Improved Street Sweeping Program II alternative, with both alternatives achieving about a 7 percent reduction in total solids, a 10 to 11 percent reduction in volatile suspended solids, a less than 1 percent reduction in nitrogen, about a 6 percent reduction in phosphorus, and a 17 to 18 percent reduction in lead. The percent removal for nitrogen is relatively low because a small portion--less than 1 percent--of the nitrogen load in stormwater runoff comes from street surfaces, which can be removed by sweeping. Conversely, the removal rate for lead is higher than for the other pollutants because a relatively large portion of the lead load in stormwater runoff--about 55 percent--originates from the street surfaces.

The evaluation indicates that for the Noyes Creek watershed, stormwater storage would remove a substantially higher percentage of the pollutant loads than would street sweeping. The Stormwater Storage I alternative would be expected to remove from 30 to 54 percent of the total existing loads from the watershed, with the highest removal rates being determined for total solids and lead, and the lowest removal rates being found for phosphorus, nitrogen, and volatile suspended solids. Pollutant loading reductions would be even higher under the Stormwater Storage II alternative, ranging from 51 percent for nitrogen and volatile suspended solids to 93 percent for total solids.

The highest level of pollutant loading reduction would be expected under the Combination alternative, consisting of improved street sweeping and stormwater storage. The stormwater storage facilities would provide most of the pollutant removal under this alternative. Pollutant loading reductions under this alternative would be about 94 percent in total solids, 81 percent in lead, 66 percent in phosphorus, 56 percent in volatile suspended solids, and 51 percent in nitrogen.

Cost: An economic analysis of the alternative nonpoint source control measures for the Noyes Creek watershed in set forth in Table V.6. The capital cost and annual operation and maintenance cost is presented for each alternative. To compare the economic aspects of the alternatives, the total present worth and equivalent annual cost of each alternative are also presented.

Under the Improved Street Sweeping Program alternatives, the 55 miles of street in the watershed would be swept at increased frequencies. An additional 329 miles of curb would be swept during six additional sweepings per year under the Improved Street Sweeping Program I alternative at an increased cost of about $900 per sweeping. Under the Improved Street Sweeping Program II alternative, an additional 714 miles of curb would be swept during 13 additional sweepings per year.

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Table V.5

POLLUTANT LOADING REDUCTIONS ANTICIPATED UNDER ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES IN THE NOYES CREEK WATERSHED

Pollutant	Existing	Improved Street Sweeping Program I		Improved Street Sweeping Program II		Stormwater Storage I		Stormwater Storage II		Combination	
	Annual Load (lbs/year)	Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction
Total Solids......	140,500	131,000	6.8	129,900	7.5	65,300	53.5	9,800	93.0	9,200	93.5
Volatile Suspended Solids......	14,650	13,150	10.2	13,100	10.6	10,300	29.7	7,200	51.0	6.450	56.0
Total Nitrogen....	4,660	4,650	0.2	4,650	0.2	3,270	29.8	2,280	51.0	2,280	51.1
Total Phosphorus..	265	250	5.7	250	5.7	170	35.8	95	65.0	90	66.0
Total Lead...	78	65	16.7	64	17.9	40	51.2	18	77.0	15	80.8

Source: SEWRPC.

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Table V.6

ECONOMIC ANALYSIS OF ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR THE NOYES CREEK WATERSHED

Cost Factor	Improved Street Sweeping Program I	Improved Street Sweeping Program II	Stormwater Storage I	Stormwater Storage II	Combination
Cost					
Capital Cost.......	$ --	$ --	$137,000	$129,000	$129,000
Annual Operation and Maintenance Cost..............	5,300	11,400	6,900	6,400	11,700
Economic Analysis (1983-2003)					
Total Present Worth.............	$53,200	$115,200	$207,000	$194,000	$247,000
Equivalent Annual Cost.......	5,300	11,400	20,500	19,200	24,500

Source: SEWRPC.

The least costly alternative, over the 20-year economic analysis period, would be the Improved Street Sweeping Program I alternative, with an estimated annual cost of about $5,300. The Improved Street Sweeping Program II alternative would be over twice as costly, with an equivalent annual cost of about $11,400. The stormwater storage alternatives would have equivalent annual costs ranging from $19,200 to $20,500, nearly two to four times the costs of the street sweeping alternatives. The Combination alternative would be the most costly alternative, with an equivalent annual cost of $24,500.

These costs can be compared to an existing annual cost for street sweeping in the Noyes Creek watershed of approximately $8,000. The alternative nonpoint source control measures evaluated herein thus are estimated to represent from 66 percent to 306 percent of the existing street sweeping costs.

Cost Effectiveness: Cost effectiveness is a measure of the cost required to remove a unit load of pollutant. For each alternative, the equivalent annual cost per pound of pollutant removed is set forth in Table V.7. The cost effectiveness analysis indicates that for the Noyes Creek watershed, the Stormwater Storage II alternative would be the most cost effective for all of the pollutants considered. The Combination alternative would be the second most cost effective alternative for all pollutants. The least cost effective alternative for all pollutants would be the Improved Street Sweeping Program II alternative.

Conclusions: The Noyes Creek watershed is a good example of a medium-density residential area with an existing street sweeping program and with several available sites suitable for modified detention basins or retention basins. The conclusions of the above analysis are as follows:

1. Improved street sweeping would remove only a modest amount of pollutants--up to 18 percent of the existing loads. Benefits are provided by intensive street sweeping in spring and fall; increased sweeping during the remainder of the sweeping season provides no significant benefits.

2. Pollutant removal levels for stormwater storage basins would be substantially higher than for street sweeping, ranging from 30 percent to more than 90 percent of the existing loads. The highest removal rates would be expected for total solids and lead.

3. The cost of stormwater storage would be relatively high--up to four times as high as the cost of improved street sweeping.

4. The cost effectiveness of improved street sweeping is substantially lower than the cost effectiveness of stormwater storage with respect to total solids, nitrogen, and phosphorus removel. However, with respect to volatile suspended solids and lead removal, improved street sweeping is within the range of cost effectiveness calculated for stormwater storage basins.

5. Combining improved street sweeping with stormwater storage increases the pollutant removal rates only slightly and is less cost effective than stormwater storage alone.

Table V.7

COST EFFECTIVENESS ANALYSIS OF ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR THE NOYES CREEK WATERSHED

Pollutant	Cost Effectiveness (equivalent annual cost per pound of pollutant removed)				
	Improved Street Sweeping Program I	Improved Street Sweeping Program II	Stormwater Storage I	Stormwater Storage II	Combination
Total Solids......	$ 0.56	$ 1.08	$ 0.27	$ 0.15	$ 0.19
Volatile Suspended Solids......	3.53	7.35	4.71	2.58	2.99
Total Nitrogen....	530.00	1,140.00	14.71	8.07	10.99
Total Phosphorus..	353.00	760.00	216.00	113.00	140.00
Total Lead........	408.00	812.00	539.00	320.00	389.00

Source: SEWRPC.

UPPER ROOT RIVER WATERSHED

Description

The Upper Root River watershed, as delineated for this study, is a 10,292-acre surface water drainage basin of which about 7,310 acres, or 71 percent of the watershed, lie within Milwaukee County and 2,982 acres, or 29 percent, lie within Waukesha County. The overall perennial length of the Upper Root River is approximately 7.6 miles. There are also about 13.8 miles of tributary intermittent streams in the watershed. For analysis purposes, the watershed was divided into 11 subbasins, as shown on Map V.3.

The soils and topography in the Upper Root River watershed have been altered by grading, excavation, and filling as a consequence of the urbanization which has occurred, and also by cultivation, ditching, and draining for agricultural purposes. The three most common soils, in order of predominance, are Ozaukee silt loam, Mequon silt loam, and Sebewa silt loam. The Ozaukee and Mequon soils are located primarily throughout the upland portions of the watershed, while the Sebewa soil is found predominantly adjacent to the surface water drainageways. These three soils generally have slow infiltration rates and are poorly drained. Consequently, they have a potential for producing higher levels of stormwater runoff and associated nonpoint source pollutant loadings compared to better drained soils. The land surface slopes in the watershed range from nearly level up to a maximum of from 12 to 20 percent, with an average land surface slope of about 3 percent.

As shown in Table V.8 and on Map V.3, urban land uses cover approximately 6,954 acres, or 68 percent of the watershed. The predominant urban land uses are residential use and transportation uses, which encompass 4,136 acres, or 40 percent, and 1,540 acres, or 15 percent of the watershed, respectively. Rural land uses cover approximately 3,338 acres, or 32 percent of the watershed. The predominant rural land uses are open land, which encompasses 1,409 acres, or about 14 percent of the watershed, and agricultural land, which encompasses 1,120 acres, or 11 percent of the watershed.

Additional data concerning the physical characteristics of the Upper Root River watershed are presented in Table V.9. Approximately 30 percent of the watershed is covered by impervious surfaces, and 75 percent of the impervious area is directly connected to a stormwater drainage system. There are about 268 curb miles of paved streets, with a curb density of about 137 curb feet per acre in the watershed. Street widths in the watershed range from 30 to 55 feet.

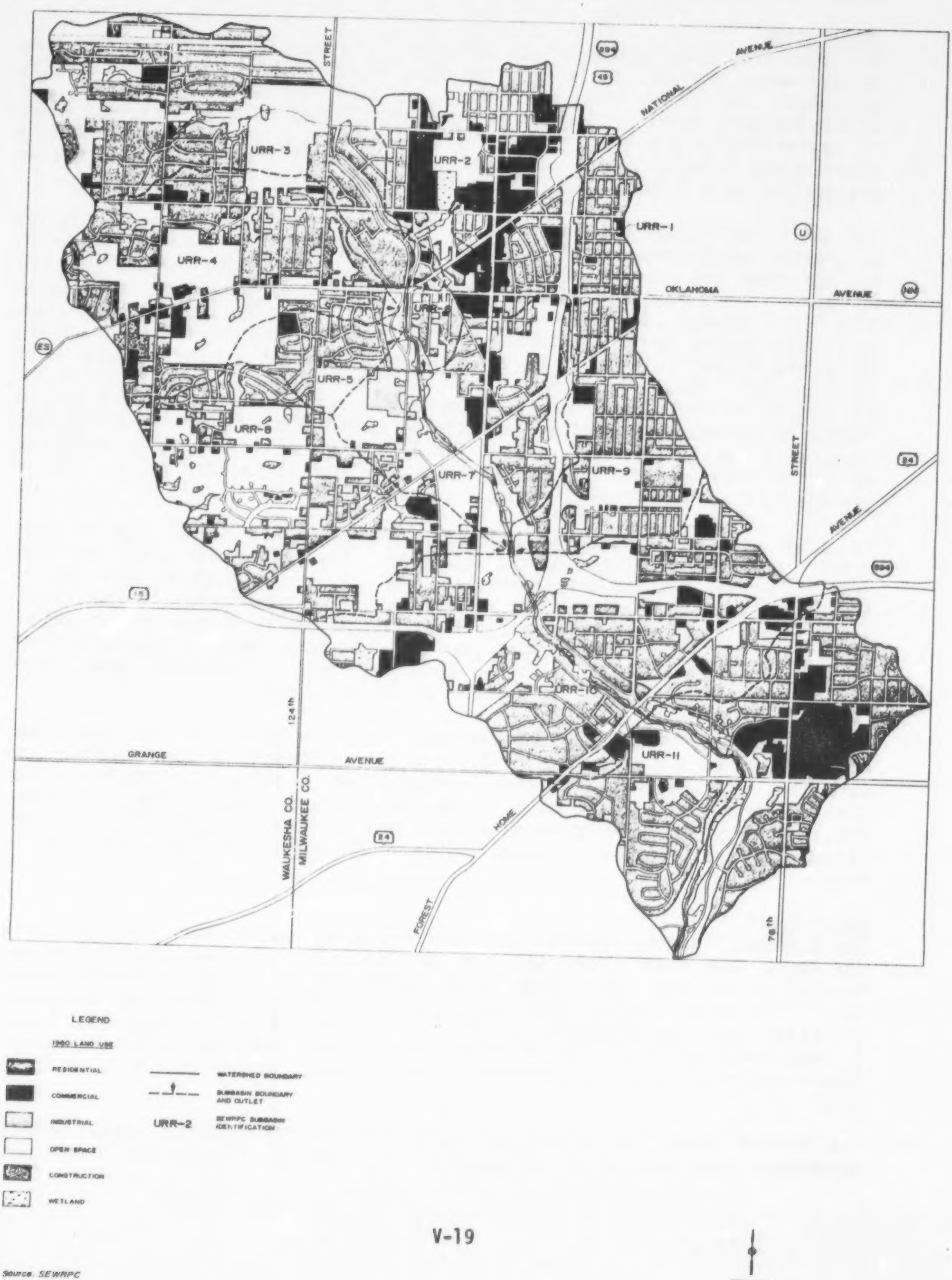
Water Quality

The Regional Planning Commission conducted a water quality sampling program in the Upper Root River watershed from 1968 to 1975. The sampling station was located on the Upper Root River at W. Grange Avenue in the Village of Greendale. The water quality data set forth in Table V.10, which was primarily collected under low streamflow conditions, indicated that the Upper Root River is moderately polluted, and characterized by occasional low dissolved oxygen levels and relatively high concentrations of total phosphorus and fecal coliform.

The adopted water use objectives set forth in the regional water quality management plan consist of maintenance of a limited fishery and associated

Map V.3

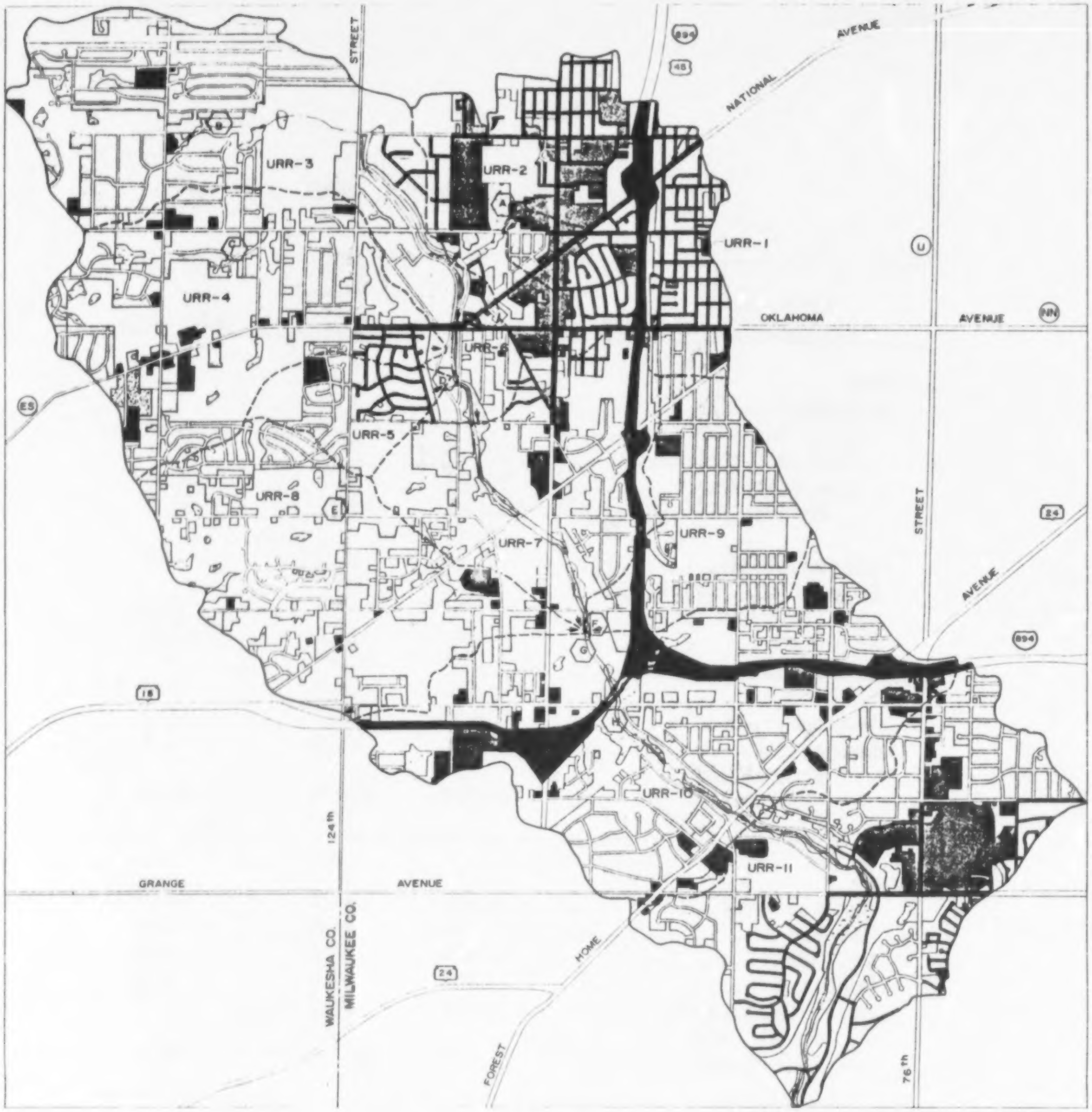
EXISTING LAND USE IN THE UPPER ROOT RIVER WATERSHED: 1980



Source: SEWRPC

Map V.4

ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR THE UPPER ROOT RIVER WATERSHED



LEGEND

1980 LAND USE

▭ RESIDENTIAL
■ COMMERCIAL
▭ INDUSTRIAL
▭ OPEN SPACE
▨ CONSTRUCTION
⁘ WETLAND

WATERSHED BOUNDARY
SUBBASIN BOUNDARY AND OUTLET
URR-2 SEWRPC SUBBASIN IDENTIFICATION
STREETS SWEEPT
(A) STORMWATER STORAGE BASIN DESIGNATION

ALTERNATIVE DESCRIPTION

ALTERNATIVE	INCREASED STREET SWEEPING	STORMWATER STORAGE
IMPROVED STREET SWEEPING PROGRAM	SPRING AND FALL ONLY	NONE
STORMWATER STORAGE	NONE	BASINS A — I
COMBINATION	SPRING AND FALL ONLY	BASINS A — I

Source: SEWRPC

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Table V.8

EXISTING LAND USE IN THE UPPER ROOT RIVER WATERSHED: 1980

Land Use Categories	Acres	Percent of Major Category	Percent of Watershed
Urban			
Residential			
High Density..........	275	4.0	2.7
Medium Density........	1,549	22.3	15.0
Low Density...........	2,312	33.2	22.5
Residential Subtotal	4,136	59.5	40.2
Construction............	23	0.3	0.2
Commercial, Utilities, and Institutional......	550	7.9	5.3
Industrial..............	25	0.4	0.2
Extractive..............	--	--	--
Parking.................	335	4.8	3.3
Transportation..........	1,540	22.1	15.0
Recreation..............	345	5.0	3.4
Urban Land Use Total	6,954	100.0	67.6
Rural			
Agricultural............	1,120	33.5	10.9
Water...................	16	0.5	0.1
Wetlands................	327	9.8	3.2
Woodlands...............	466	14.0	4.5
Other Open Lands........	1,409	42.2	13.7
Rural Land Use Total	3,338	100.0	32.4
Total	10,292	--	100.0

Source: SEWRPC.

Table V.9

SELECTED PHYSICAL CHARACTERISTICS OF UPPER ROOT RIVER WATERSHED: 1980

Subbasin[a]	Areal Extent (acres)	Percent Impervious	Percent Impervious Directly Connected to Stormwater Drainage System	Street Width (feet)	Curb Length (miles)	Curb Density (feet/acre)
URR-1	578	52	83	45	29.9	273.3
URR-2	685	51	89	50	22.8	175.7
URR-3	1,302	26	66	35	30.1	122.1
URR-4	1,216	21	61	35	25.9	112.5
URR-5	259	28	62	30	7.7	156.0
URR-6	134	16	59	45	4.1	162.7
URR-7	915	23	77	55	21.7	125.0
URR-8	1,210	18	63	35	18.9	82.3
URR-9	604	34	74	35	21.4	186.8
URR-10	1,891	31	78	50	44.8	125.0
URR-11	1,498	34	77	45	40.2	141.5
Total	10,292	30	75	--	267.5	137.2

[a] Denotes SEWRPC-delineated subbasin numbers in the Upper Root River watershed.

Source: SEWRPC.

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Table V.10

WATER QUALITY CONDITIONS IN THE UPPER ROOT RIVER AT W. GRANGE AVENUE, VILLAGE OF GREENDALE: 1968-1975

Parameter[a]	Maximum	Mean	Minimum	Number of Analyses
Chloride	395	147	48	22
Specific Conductance (umhos/cm at 25°C)	1,733	1,103	464	30
Dissolved Oxygen	9.9	5.2	2.2	30
Ammonia Nitrogen	0.44	0.25	0.03	8
Organic Nitrogen	1.19	0.80	0.10	8
Nitrite Nitrogen	0.28	0.11	0.00	12
Nitrate Nitrogen	1.08	0.44	0.12	12
Total Nitrogen	2.89	1.62	0.22	8
Total Phosphorus	0.53	0.18	0.07	8
Fecal Coliform (MFFCC/100 ml)	32,000	3,253	140	12
Temperature (°F)	77.0	69.9	59.5	30
pH (standard units)	8.3	7.9	7.6	22

[a] All parameters expressed in milligrams per liter (mg/l) except as noted.

Source: SEWRPC.

aquatic life and limited recreational use for the 2.9 miles of the river main stem located upstream of W. Layton Avenue in the City of Greenfield (SEWRPC, 1979). These limited use objectives for this reach of the Upper Root River are due to committed channelization of this reach with the eventual placement of concrete lining. For the remaining 4.7 miles of the Root River main stem, as well as for all of the tributary streams, the water use objectives are for the maintenance of warmwater fish and aquatic life, and for recreational use.

The suitability of the observed water quality conditions for supporting the adopted water uses may be determined by comparing the measured water quality data to recommended water quality standards. Of the water quality parameters shown in Table V.10, the regional water quality management plan recommended standards to support recreational use and warmwater fish and aquatic life for dissolved oxygen, un-ionized ammonia nitrogen, total phosphorus, fecal coliform, temperature, and pH. The mean dissolved oxygen level measured was only slightly above the minimum standard of 5.0 mg/l, and more than one half of the measurements taken were less than, and thus violated, the standard. These low concentrations of dissolved oxygen may be harmful to desired fish and aquatic life communities. The mean total phosphorus level measured is nearly twice the recommended maximum standard of 0.1 mg/l, with 75 percent of the measurements violating the recommended standard. Excessive levels of phosphorus can result in excessive weed and algal growths which interfere with recreational uses of the water and which can create stressful conditions for fish and aquatic life. The fecal coliform standard of a maximum of 400 MFFCC/100 ml was violated by 67 percent of the measurements taken. High levels of fecal coliform can pose a threat to human health and safety. The temperature, pH, and un-ionized ammonia nitrogen standards were generally not violated in the Upper Root River.

The water quality conditions set forth in Table V.10 were determined by both point and nonpoint sources of water pollution. Urban practices recommended in the regional water quality management plan to be considered for nonpoint source control in the upper Root River watershed include increased street sweeping, leaf and vegetative debris collection, and catch basin cleaning; construction site erosion control; streambank protection; pet waste and litter control; industrial and commercial site runoff control; improved management of onsite sewage disposal systems; and the conduct of public education programs to inform property owners as to the importance of proper use and disposal of fertilizers and other practices to help improve water quality.

Description of Alternative Nonpoint Source Control Measures

This section describes the street sweeping programs and the use of modified detention basins or retention basins as alternative nonpoint source control measures for the Upper Root River watershed. An improved street sweeping program alternative was developed, as well as an alternative which includes the use of stormwater storage facilities--modified detention basins or retention basins--where appropriate, along with the existing street sweeping program. Finally, an alternative was developed which included the stormwater storage facilities used in combination with an improved street sweeping program. Improved street sweeping was considered only for those communities which currently conduct street sweeping programs. The specific nonpoint source control measures--street sweeping program, and location, size, and drainage area of any modified detention basins or retention basins--assumed for each alternative are set forth in Table V.11.

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Table V.11

DESCRIPTION OF NONPOINT SOURCE CONTROL ALTERNATIVES FOR THE UPPER ROOT RIVER WATERSHED

		Modified Detention Basins or Retention Basins		
Alternative	Street Sweeping Frequency[a]	Location (Subbasin)	Basin Area (Acres)	Tributary Drainage Area (Acres)
Existing Street Sweeping Program	Sweep all commercial streets in the City of West Allis once per week and all other streets with curb and gutter once every two weeks; sweep all streets with curb and gutter in the Village of Greendale once per week; sweep all freeways in the watershed once every two months. All sweeping occurs from March through November.	None	None	None
Improved Street Sweeping Program	Within the City of West Allis, sweep all commercial streets an additional 9 times in March and sweep all other streets an additional 3 times in March and 2 times in October; within the Village of Greendale, sweep all commercial streets an additional 9 times in March and sweep all other streets an additional 3 times in March; sweep all freeways in the watershed an additional 3 times in March.	None	None	None
Stormwater Storage	Sweep all commercial streets in the City of West Allis once per week and all other streets with curb and gutter once every two weeks; sweep all streets with curb and gutter in the Village of Greendale once per week; sweep all freeways in the watershed once every two months. All sweeping occurs from March through November.	Basin A-URR2	2	552
		Basin B-URR3	1	479
		Basin C-URR4	1	244
		Basin D-URR5	1	262
		Basin E-URR8	1	376
		Basin F-URR9	2	607
		Basin G-URR10	1	135
		Basin H-URR10	1	258
		Basin I-URR10	1	385
Combination Stormwater Storage and Improved Street Sweeping	Within the City of West Allis, sweep all commercial streets an additional 9 times in March and sweep all other streets an additional 3 times in March and 2 times in October; within the Village of Greendale, sweep all commercial streets an additional 9 times in March and sweep all other streets an additional 3 times in March; sweep all freeways in the watershed an additional 3 times in March.	Basin A-URR2	2	552
		Basin B-URR3	1	479
		Basin C-URR4	1	244
		Basin D-URR5	1	262
		Basin E-URR8	1	376
		Basin F-URR9	2	607
		Basin G-URR10	1	135
		Basin H-URR10	1	258
		Basin I-URR10	1	385

[a] Applies only to those streets as shown in Map V.4, which have curb and gutter.

Source: SEWRPC

Existing pollutant loadings are estimated in order to provide baseline conditions. Within the Upper Root River watershed, street sweeping is currently conducted only by the City of West Allis, the Village of Greendale, and by Milwaukee County on the freeway system and on certain county highways. For the purposes of the simulation modeling, it was assumed that only the streets with curb and gutter and within the City of West Allis or within the Village of Greendale, plus the freeways throughout the watershed, are currently swept. Within the City of West Allis, it was assumed that commercial streets are swept once per week and that all other surface streets are swept once every two weeks (SEWRPC, 1980). Within the Village of Greendale, it was assumed that all street surfaces are swept once per week. It was assumed that all freeways are swept about once every two months. Street sweeping generally extends from March through November. The streets which are swept are illustrated on Map V.4.

The "Improved Street Sweeping Program" alternative, as shown on Map V.4, includes increased sweeping within the City of West Allis, the Village of Greendale, and all of the freeways within the watershed. Within the City of West Allis, all commercial streets would be swept an additional nine times in March. All other streets in the City of West Allis with curb and gutter would be swept an additional three times in March and two times in October. Increased sweeping during October was not deemed necessary for the commercial streets because of lower leaf and vegetative accumulations expected in commercial areas and because the commercial streets are already swept once per week. Within the Village of Greendale, all commercial streets would be swept an additional nine times in March and all other streets would be swept an additional three times in March. No increased sweeping would occur during October in the Village of Greendale because the streets are already swept once per week. All freeways in the watershed would be swept an additional three times during March. All street sweeping during the remaining months would be the same as the existing frequency. The "Improved Street Sweeping Program" alternative assumes that sweeping operations would be properly and efficiently conducted in accordance with the methods set forth in Table III.3 of Chapter III.

The "Stormwater Storage" alternative for the Upper Root River watershed would involve the use of nine modified detention basins or retention basins, each ranging in size from one to two acres, to temporarily store stormwater runoff from a total of about 3,300 acres, or about 32 percent of the entire Upper Root River watershed. Map V.4 shows the locations of the nine basins evaluated for this alternative. The "Stormwater Storage" alternative includes the existing street sweeping program.

The "Combination" alternative consists of the "Improved Street Sweeping" alternative used in combination with the nine stormwater storage basins developed for the "Stormwater Storage" alternative.

Evaluation of Alternatives

An evaluation of the pollutant removal effectiveness, cost, and cost effectiveness of the alternative nonpoint source control measures is presented below. It is recognized, however, that management decisions cannot be based entirely on water quality impacts, but that other factors which must be addressed by local governmental agencies also influence decision making. These factors include economics, political and public acceptance, skills and resources, maintenance requirements, management considerations, and safety and nuisance factors.

Pollutant Removal: Pollutant removal levels expected to be achieved by each of the alternative nonpoint source control measures evaluated for the Upper Root River watershed are set forth in Table V.12. The table indicates that the Improved Street Sweeping alternative would be expected to remove an insignificant amount--less than 3 percent--of the existing pollutant loadings. A relatively lower level of pollutant removal would be achieved for the Upper Root River watershed than for the Noyes Creek watershed because streets within less than one half of the Upper Root River watershed would be swept, and because those communities which do have street sweeping programs currently sweep their streets relatively frequently--two to four times per month--so that further pollutant reductions are more difficult to achieve. The table also indicates that the Stormwater Storage alternative would remove from 14 to 25 percent of the existing pollutant loadings from the watershed. Again, these removal levels are less than for the Noyes Creek watershed because in the Noyes Creek watershed from 61 percent to 100 percent of the watershed would drain to stormwater storage basins, while for the Upper Root River watershed, only 32 percent of the watershed would drain to stormwater storage basins.

Under the Combination alternative, consisting of improved street sweeping and stormwater storage, pollutant loading reductions are very similar to the Stormwater Storage alternative. Pollutant loading reductions under this alternative are about 25 percent in total solids, 21 percent in lead, 17 percent in phosphorus, 16 percent in volatile suspended solids, and 14 percent in nitrogen.

Cost: An economic analysis of the alternative nonpoint source control measures for the Upper Root River watershed is set forth in Table V.13. The capital cost and annual operation and maintenance cost is presented for each alternative. To compare the economic aspects of the alternatives, the total present worth and equivalent annual cost of each alternative are also presented.

Under the Improved Street Sweeping Program alternative, the 78.8 curb miles of street, plus the 6.4 miles of freeway, which would be swept would entail an increased cost of nearly $1,900 per sweeping. An additional 580 miles of curb or freeway lane would be swept per year under the Improved Street Sweeping Program alternative. Of the total estimated equivalent annual cost of about $8,500, about $1,700, or 20 percent, would be for the increased sweeping of commercial streets; $5,000, or about 59 percent, would be for the increased sweeping of residential and other streets; and the remaining $1,800, or 21 percent, would be for increased sweeping of the freeways. Over the 20-year, economic analysis period, the Improved Street Sweeping Program alternative is the least costly alternative evaluated for the Upper Root River watershed.

The Stormwater Storage alternative has an equivalent annual cost of about $83,000, nearly 10 times the cost of the Improved Street Sweeping Program alternative. The capital cost of the individual stormwater storage basins evaluated would range from about $57,000 to $81,000, with a total estimated capital cost of $558,000. The annual operation and maintenance cost of the Stormwater Storage alternative of about $28,000 is over three times the operation and maintenance cost of the Improved Street Sweeping Program alternative.

The Combination alternative is the most costly alternative, with an equivalent annual cost of $91,000. Under the Combination alternative, the capital cost

Table V.12

POLLUTANT LOADING REDUCTIONS ANTICIPATED UNDER ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES IN THE UPPER ROOT RIVER WATERSHED

Pollutant	Existing Annual Load (lbs/year)	Improved Street Sweeping Program		Stormwater Storage		Combination	
		Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction
Total Solids......	1,820,400	1,807,900	0.7	1,374,300	24.5	1,365,000	25.0
Volatile Suspended Solids......	109,800	108,400	1.3	93,800	14.6	92,550	15.7
Total Nitrogen....	43,470	43,465	0.01	37,480	13.8	37,470	13.8
Total Phosphorus..	3,015	3,000	0.5	2,525	16.3	2,510	16.7
Total Lead...	548	536	2.2	444	19.0	432	20.8

Source: SEWRPC.

Table V.13

ECONOMIC ANALYSIS OF ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR THE UPPER ROOT RIVER WATERSHED

Cost Factor	Improved Street Sweeping Program	Stormwater Storage	Combination
Cost			
Capital Cost.......	$ --	$558,000	$558,000
Annual Operation and Maintenance Cost.............	8,500	27,600	36,100
Economic Analysis (1983-2003)			
Total Present Worth............	$85,800	$837,000	$923,000
Equivalent Annual Cost.......	8,500	83,000	91,000

Source: SEWRPC.

would be the same as for the Stormwater Storage alternative, but the annual operation and maintenance cost would be the sum of the costs associated with the Stormwater Storage and Improved Street Sweeping Program alternatives. The equivalent annual cost of the Combination alternative is 10 percent higher than the annual cost of the Stormwater Storage alternative, and nearly 11 times the annual cost of the Improved Street Sweeping alternative.

These costs can be compared to an existing annual cost for street sweeping in the Upper Root River watershed of approximately $35,000. The alternative nonpoint source control measures evaluated herein thus are estimated to represent from 24 percent to 260 percent of the existing street sweeping costs.

Cost Effectiveness: Cost effectiveness is a measure of the cost required to remove a unit load of pollutant. For each alternative, the equivalent annual cost per pound of pollutant removed is set forth in Table V.14. The cost effectiveness analysis indicates that for the Upper Root River watershed, the Stormwater Storage alternative is the most cost effective for all of the pollutants considered, except for lead, for which the Improved Street Sweeping and Combination alternatives would be slightly more cost effective. The Combination alternative is the second most cost effective alternative for all pollutants.

Conclusions: The Upper Root River watershed is a good example of a developing residential area with substantial interspersed open land areas. An improved street sweeping program was found applicable to only a relatively small portion of the watershed, and, although several potential sites were available for stormwater storage basins, such basins would receive stormwater drainage from a relatively small portion of the total watershed. Hence, pollutant loading reductions achieved by both improved street sweeping and stormwater storage are much less than the reductions which could be achieved for a fully developed watershed which could be drained entirely to a stormwater storage basin, such as the Noyes Creek watershed. The specific conclusions of the above analysis are as follows:

1. Improved street sweeping would remove only an insignificant amount of the total pollutant loads in the watershed--less than 3 percent of the existing loads.

2. Pollutant removal levels for the Stormwater Storage alternative would be substantially higher than for improved street sweeping, ranging from 14 to 25 percent of the existing loads. The highest removal rates may be expected for total solids and lead.

3. The cost of stormwater storage is relatively high--nearly 10 times the cost of improved street sweeping.

4. The cost effectiveness of improved street sweeping is substantially lower than the cost effectiveness of stormwater storage with respect to total solids, nitrogen, and phosphorus. However, for volatile suspended solids removal, the cost effectiveness of improved street sweeping is similar to that of stormwater storage, and for lead removal, improved street sweeping is actually slightly more cost effective than is stormwater storage. However, for the Upper Root

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Table V.14

COST EFFECTIVENESS ANALYSIS OF ALTERNATIVE
NONPOINT SOURCE CONTROL MEASURES
FOR THE UPPER ROOT RIVER WATERSHED

	Cost Effectiveness (equivalent annual cost per pound of pollutant removed)		
Pollutant	Improved Street Sweeping Program	Stormwater Storage	Combination
Total Solids.....	$ 0.68	$ 0.19	$ 0.20
Volatile Suspended Solids	6.07	5.18	5.30
Total Nitrogen....	1,700.00	13.84	15.23
Total Phosphorus..	567.00	169.00	181.00
Total Lead........	708.00	797.00	788.00

Source: SEWRPC

River watershed, the cost effectiveness of improved street sweeping is of little practical significance since only a negligible amount of removal can be achieved by the practice.

5. Combining improved street sweeping with stormwater storage increases the pollutant removal rates only slightly, and except for lead, is less cost effective than stormwater storage alone.

LINCOLN CREEK WATERSHED

Description

The Lincoln Creek watershed is a surface water drainage basin approximately 12,923 acres, or 20.19 square miles in areal extent. Approximately 12,372 acres, or 96 percent of the watershed, lie within the City of Milwaukee; with 441 acres, or 3 percent, within the City of Glendale; and 110 acres, or 1 percent, within the Village of Brown Deer. Lincoln Creek is a perennial stream approximately 9 miles in length which is tributary to the Milwaukee River. For analysis purposes, the watershed was divided into 18 subbasins, as shown on Map V.5.

The soils and topography in the Lincoln Creek watershed have been altered by grading, excavation, and filling as a consequence of the urbanization which has occurred. The three most common soils, in order of predominance, are Mequon silt loam, Ozaukee silt loam, and Ashkum silt loam. The Ozaukee and Mequon soils are located primarily throughout the upland portions of the watershed, while the Ashkum soil is found predominantly adjacent to the surface water drainageways. These three soils generally have slow infiltration rates and are poorly drained. Consequently, they have a potential for producing higher levels of stormwater runoff and associated nonpoint source pollutant loadings compared to better drained soils. The land surface slopes in the watershed range from nearly level up to a maximum of 10 percent, with an average land surface slope of about 2 percent.

As shown in Table V.15 and on Map V.5, urban land uses cover approximately 11,454 acres, or 89 percent of the watershed. The predominant urban land uses are high-density residential use and transportation uses, which encompass 4,051 acres, or 31 percent, and 3,231 acres, or 25 percent of the watershed, respectively. Rural land uses cover approximately 1,469 acres, or 11 percent of the watershed. The predominant rural land use is open land, which encompasses 1,239 acres, or about 10 percent of the watershed.

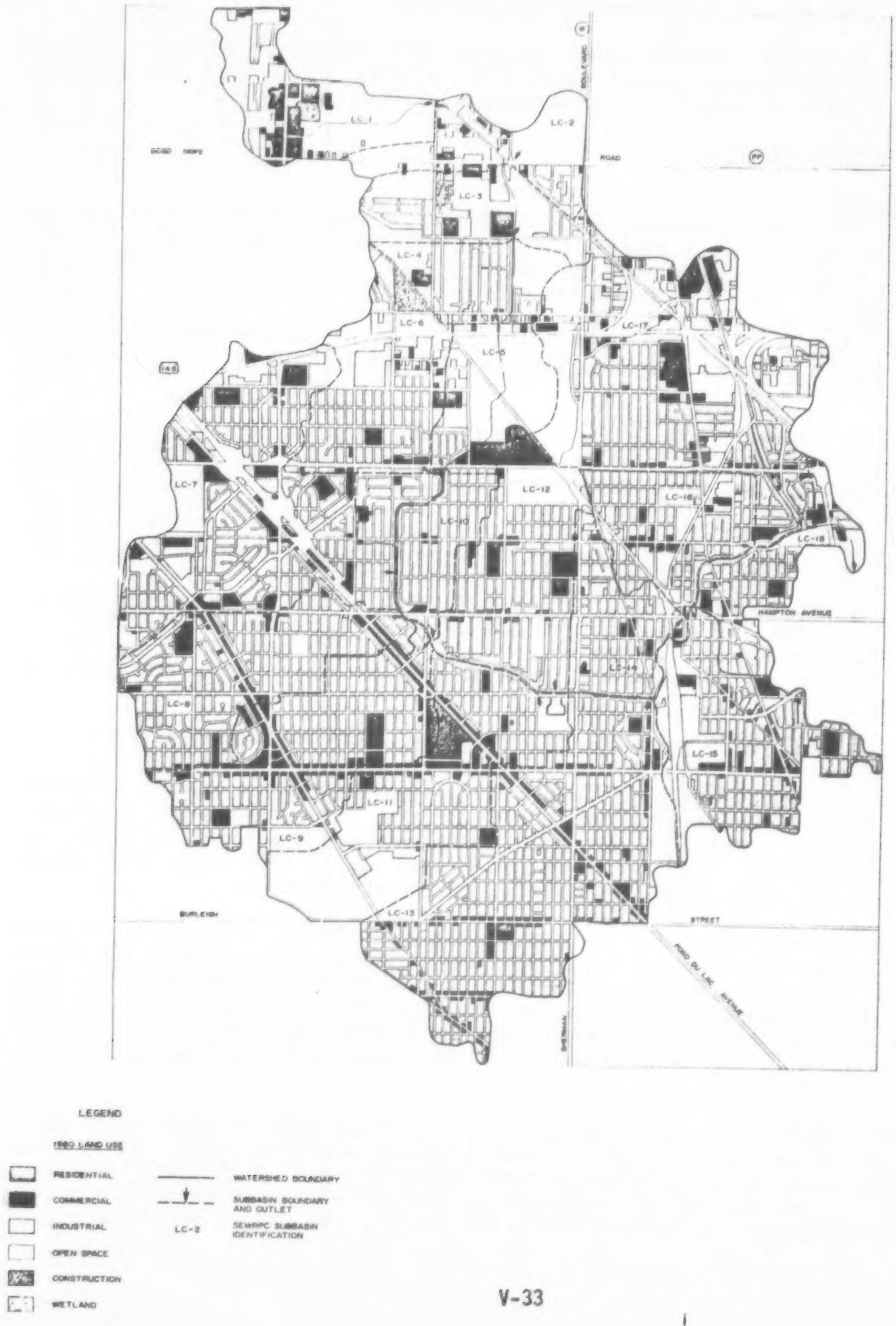
Additional data concerning the physical characteristics of the Lincoln Creek watershed are presented in Table V.16. Approximately 54 percent of the watershed is covered by impervious surfaces, and 90 percent of the impervious area is directly connected to the storm sewer system. There are about 586 curb miles of paved streets, with a curb density of about 240 curb feet per acre in the watershed. The average street width ranges from 35 feet to 65 feet.

Water Quality

The Southeastern Wisconsin Regional Planning Commission collected water quality samples on Lincoln Creek at Cameron Avenue, approximately 1.5 miles above the confluence with the Milwaukee River during the fall of 1976 and the spring of 1977. The sampling was conducted as part of the Commission regional water quality management planning efforts, and the data are summarized in Table V.17.

Map V.5

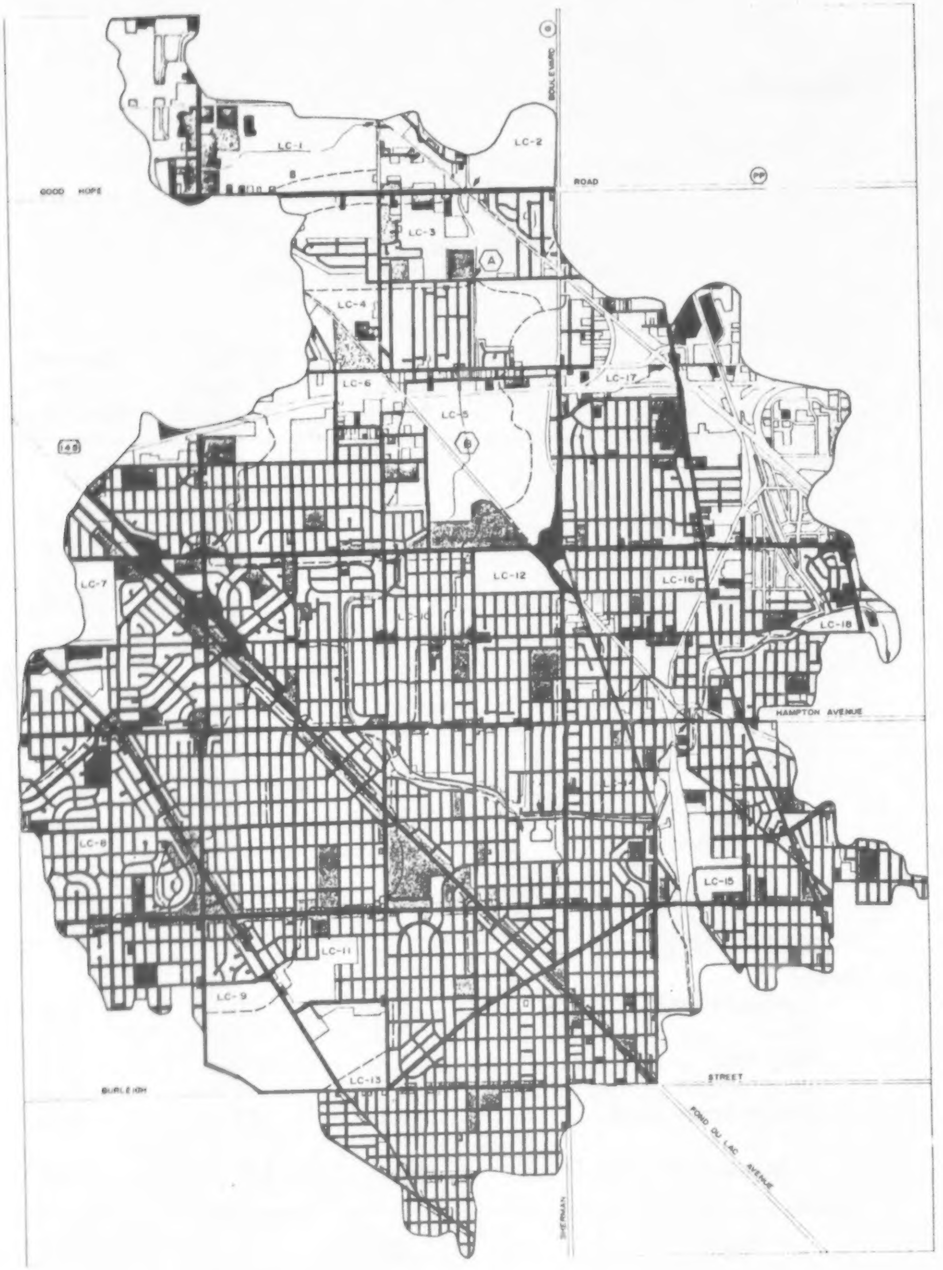
EXISTING LAND USE IN THE LINCOLN CREEK WATERSHED: 1980



Source SEWRPC

Map V.6

ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR THE LINCOLN CREEK WATERSHED



LEGEND

1980 LAND USE

▭	RESIDENTIAL
■	COMMERCIAL
▭	INDUSTRIAL
▭	OPEN SPACE
▨	CONSTRUCTION
▭	WETLAND

—	WATERSHED BOUNDARY
— ↓ —	SUBBASIN BOUNDARY AND OUTLET
LC-8	SEWRPC SUBBASIN IDENTIFICATION
━	STREETS SWEPT
⬡ A	STORMWATER STORAGE BASIN DESIGNATION

Source SEWRPC

ALTERNATIVE DESCRIPTION

ALTERNATIVE	INCREASED STREET SWEEPING	STORMWATER STORAGE
IMPROVED STREET SWEEPING PROGRAM I	SPRING AND FALL ONLY	NONE
IMPROVED STREET SWEEPING PROGRAM II	ENTIRE SWEEPING SEASON	NONE
STORMWATER STORAGE	NONE	BASINS A AND B
COMBINATION	SPRING AND FALL ONLY	BASINS A AND B

Table V.15

EXISTING LAND USE IN THE LINCOLN CREEK WATERSHED: 1980

Land Use Categories	Acres	Percent of Major Category	Percent of Watershed
Urban			
Residential			
High Density	4,051	35.4	31.3
Medium Density	1,029	9.0	8.0
Low Density	154	1.3	1.2
Residential Subtotal	5,234	45.7	40.5
Construction	45	0.4	0.3
Commercial, Utilities, and Institutional	781	6.8	6.0
Industrial	576	5.0	4.5
Landfill	15	0.2	0.1
Parking	552	4.8	4.3
Transportation	3,231	28.2	25.0
Recreation	1,020	8.9	7.9
Urban Land Use Total	11,454	100.0	88.6
Rural			
Agricultural	160	10.9	1.2
Water	21	1.4	0.2
Wetlands	14	1.0	0.1
Woodlands	35	2.4	0.3
Other Open Lands	1,239	84.3	9.6
Rural Land Use Total	1,469	100.0	11.4
Total	12,923	--	100.0

Source: SEWRPC.

Table V.16

SELECTED PHYSICAL CHARACTERISTICS OF THE LINCOLN CREEK WATERSHED: 1980

Subbasin[a]	Areal Extent (acres)	Percent Impervious	Percent Impervious Directly Connected to Storm Sewer System	Street Width (feet)	Curb Length (miles)	Curb Density (feet/acre)
LC-1.....	507	28	83	35	8.5	89.0
LC-2.....	372	37	81	60	7.7	109.6
LC-3.....	424	26	78	40	8.0	100.0
LC-4.....	323	30	71	40	10.2	167.1
LC-5.....	390	29	87	40	5.6	75.6
LC-6.....	602	56	92	40	25.3	221.7
LC-7.....	1,373	53	87	55	50.5	194.0
LC-8.....	790	58	89	45	49.0	327.7
LC-9.....	915	62	91	40	52.3	302.0
LC-10....	411	54	86	35	23.8	305.7
LC-11....	963	49	89	40	39.7	217.4
LC-12....	700	58	91	40	31.2	235.4
LC-13....	1,631	66	93	40	109.8	355.4
LC-14....	361	63	93	50	23.7	346.3
LC-15....	781	69	94	40	41.3	279.1
LC-16....	485	64	92	35	23.9	260.6
LC-17....	1,551	54	92	40	60.2	204.8
LC-18....	344	55	91	50	15.5	237.8
Total	12,923	54	90	--	586.2	239.5

[a] Denotes SEWRPC-delineated subbasin numbers in the Lincoln Creek watershed.

Source: SEWRPC.

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Table V.17

WATER QUALITY CONDITIONS IN LINCOLN CREEK AT CAMERON AVENUE, CITY OF MILWAUKEE: NOVEMBER 1976 - APRIL 1977

Parameter[a]	Maximum	Mean	Minimum	Number of Analyses
Chloride	2,216	226	26	30
Specific Conductance (umhos/cm at 25°C)	6,829	1,022	397	30
Dissolved Oxygen	14.7	10.3	5.4	30
Ammonia Nitrogen	0.32	0.07	0.03	30
Organic Nitrogen	2.16	0.68	0.06	30
Nitrite Nitrogen	0.177	0.035	0.004	30
Nitrate Nitrogen	2.36	0.49	0.03	30
Total Nitrogen	2.99	1.26	0.18	30
Phosphate Phosphorus	0.223	0.095	0.018	29
Soluble Reactive Phosphorus	0.144	0.089	0.017	18
Total Phosphorus	0.86	0.20	0.04	26
Fecal Coliform (MFFCC/100 ml)	50,000.0	6,200.0	20.0	29
Temperature (°F)	57.0	45.0	36.0	29
pH (standard units)	7.8	7.5	7.0	12
Biochemical Oxygen Demand	55.0	7.2	0.0	30
Total Suspended Solids	346.0	97.0	1.0	12

[a] All parameters expressed in milligrams per liter (mg/l) except as noted.

Source: SEWRPC

Water quality sampling on Lincoln Creek has also been conducted by the Wisconsin Department of Natural Resources under the Milwaukee River watershed basin surveys and by the Milwaukee Metropolitan Sewerage District. The water quality data set forth in Table V.17 indicate that Lincoln Creek is moderately polluted, characterized by relatively high levels of fecal coliform, chloride, phosphorus, and biochemical oxygen demand.

For Lincoln Creek, the adopted water use objectives set forth in the regional water quality management plan consist of the maintenance of limited fish and associated aquatic life and limited recreational use (SEWRPC, 1979). The Department of Natural Resources currently grants a variance to Lincoln Creek, requiring less restrictive standards for dissolved oxygen and for fecal coliform than are required for a stream classified for warmwater fish and aquatic life and recreational use. The suitability of the observed water quality conditions for supporting the adopted water uses may be determined by comparing the measured water quality data to recommended water quality standards. Of the water quality parameters shown in Table V.17, the regional water quality management plan recommended standards to support limited fish and aquatic life and limited recreational use for dissolved oxygen, un-ionized ammonia nitrogen, fecal coliform, temperature, and pH. All of the observed dissolved oxygen levels were well above the minimum standard of 3.0 mg/l. However, all of the measurements were taken during those months--November through early April--when dissolved oxygen problems may not occur even in those streams which do experience dissolved oxygen problems during the summer. The fecal coliform standard of a maximum of 400 MFFCC/100 ml was violated by 72 percent of the measurements taken. The temperature, pH, and un-ionized ammonia nitrogen standards were not violated in Lincoln Creek.

The water quality conditions set forth in Table V.17 were the result of both point and nonpoint sources of water pollution. A minimum level of nonpoint source pollution control was recommended in the adopted regional water quality management plan for the Lincoln Creek watershed. Urban practices recommended to be considered to achieve the minimum level of control include improved urban "housekeeping" practices such as improved timing and efficiency of street sweeping, leaf and vegetative debris collection, and catch basin cleaning; construction site erosion control; pet waste and litter control; and the conduct of public education programs to inform property owners as to the importance of proper use and disposal of fertilizers and other practices to help improve water quality.

Description of Alternative Nonpoint Source Control Measures

This section describes the street sweeping programs and the use of modified detention basins or retention basins as alternative nonpoint source control measures for the Lincoln Creek watershed. Two improved street sweeping program alternatives were developed. One alternative was developed which included the use of stormwater storage facilities--modified detention basins or retention basins--where appropriate, along with the existing street sweeping program. Finally, an alternative was developed which included stormwater storage facilities used in combination with an improved street sweeping program. The specific nonpoint source control measures, street sweeping program, and location, size, and drainage area of any modified detention basins or retention basins assumed for each alternative are set forth in Table V.18.

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Table V.18

DESCRIPTION OF NONPOINT SOURCE CONTROL ALTERNATIVES FOR THE LINCOLN CREEK WATERSHED

		Modified Detention Basins or Retention Basins		
Alternative	Street Sweeping Frequency[a]	Location (Subbasin)	Basin Area (Acres)	Tributary Drainage Area (Acres)
Existing Street Sweeping Program	Sweep all streets once per month from March through November.	None	None	None
Improved Street Sweeping Program I	Sweep all residential streets an additional 3 times and commercial streets an additional 9 times in March; sweep all streets an additional 3 times in October; sweep all streets once per month for the remainder of the sweeping season.	None	None	None
Improved Street Sweeping Program II	Sweep all residential streets an additional 3 times and commercial streets an additional 9 times in March; sweep all streets an additional 3 times in October, sweep all streets an additional once per month for the remainder of the sweeping season.	None	None	None
Stormwater Storage	Sweep all streets once per month from March through November.	Basin A - LC3	16	1,303
		Basin B - LC-5	5	1,746
Combination Stormwater Storage and Improved Street Sweeping Program I	Sweep all residential streets an additional 3 times and commercial streets an additional 9 times in March; sweep all streets an additional 3 times in October; sweep streets once per month for the remainder of the sweeping season.	Basin A - LC-3	16	1,303
		Basin B - LC-5	5	1,746

[a] Applies only to those streets as shown on Map V.6, which have curb and gutter.

Source: SEWRPC.

Existing pollutant loadings are estimated in order to provide baseline conditions. Within the Lincoln Creek watershed, the vast majority of the streets in the highly developed urban areas are currently swept an average of once per month approximately from March through November. The streets which are swept are illustrated on Map V.6. Only a few streets in the northern and western portions of the watershed, especially within the Village of Glendale, do not have curb and gutter and hence, are not swept, as shown on the map.

Two improved street sweeping alternatives are evaluated. The "Improved Street Sweeping Program I" alternative, as shown on Map V.6, includes an intensive street sweeping effort in early spring--sweeping all residential streets an additional three times and all commercial streets an additional nine times during March--to reduce high spring street surface loadings prior to the onset of heavy spring rainstorms. In addition, street sweeping would be intensified --sweeping both residential and commercial streets at a frequency of once per week--during October to reduce high fall loadings, including leaves and other vegetative debris. During the remainder of the sweeping season--from March through November--all streets would be swept at the existing frequency--once per month. The second improved street sweeping alternative, "Improved Street Sweeping Program II", illustrated on Map V.6, also includes the intensive sweeping efforts in spring and in fall. However, this second alternative also includes sweeping all streets at an increased frequency--an additional once per month, during the remainder of the sweeping season. Both of the improved street sweeping alternatives assume that sweeping operations would be properly and efficiently conducted in accordance with the methods set forth in Table III.3 of Chapter III.

One stormwater storage alternative was also evaluated for the Lincoln Creek watershed. In general, because of the highly urbanized nature of the watershed, there are very few open land sites available which could potentially be utilized for stormwater storage. However, two such sites were identified in SEWRPC Community Assistance Planning Report No. 13 (2nd Edition), Flood Control Plan for Lincoln Creek, Milwaukee County, Wisconsin (1982) as possible locations for stormwater storage basins. Although the SEWRPC report concluded that stormwater storage basins at the proposed sites would not provide substantial flood control benefits, the water quality benefits of these basins will be evaluated in this chapter. Unfortunately, both of these sites are located in the headwater portion of the watershed, and neither would receive drainage from the high density urban development which covers most of the watershed. No open land sites suitable for stormwater storage basins were identified in the lower portion of the watershed. In addition to the two open sites identified in SEWRPC Community Assistance Planning Report No. 13, there is currently a series of 11 ponds located in subbasin LC-1 on the Brynwood Country Club property, immediately west of N. 60th Street in the City of Milwaukee. Because of the relatively small drainage area to these ponds, and because the analytical techniques used cannot accurately predict the pollutant removal efficiency of a series of small ponds, these ponds are not considered in the analysis presented in this chapter.

Basin A, as shown on Map V.6, would be located in subbasin LC-3 and would lie between W. Good Hope Road and W. Green Tree Road. As developed in SEWRPC Community Assistance Planning Report No. 13, the 16-acre basin would have a mean depth of 5.25 feet and a storage capacity of 84 acre-feet. Subbasins LC-1, LC-2, and LC-3, with an area of 1,303 acres, or 10 percent of the total watershed area, would drain to Basin A. Basin B, also as shown on Map V.6, would be located just upstream of the Wisconsin and Southern Railroad tracts in subbasin LC-5, within the Department of Natural Resources' Havenwoods Urban Environmental Education Center. The five-acre basin would have a mean depth of five feet and a storage capacity of 25 acre-feet. Subbasins LC-1, LC-2, LC-3, LC-4, and part of LC-5, with an area of 1,746 acres, or 14 percent of the total watershed area, would drain to Basin B. The "Stormwater Storage" alternative includes the existing street sweeping program.

A "Combination" alternative was also developed and includes the two stormwater storage basins used in the "Stormwater Storage" alternative in combination with the "Improved Street Sweeping Program I" alternative.

Evaluation of Alternatives

An evaluation of the pollutant removal effectiveness, cost, and cost effectiveness of the alternative nonpoint source control measures is presented below. It is recognized, however, that management decisions cannot be based entirely on water quality impacts; other factors which must be addressed by local governmental agencies must also influence decision making. These factors include economics, political and public acceptance, skills and resources, maintenance requirements, management considerations, and safety and nuisance factors.

Pollutant Removal: Pollutant removal levels expected to be achieved by each of the alternative nonpoint source control measures evaluated for the Lincoln Creek watershed are set forth in Table V.19. The table indicates that there is a slight difference between the Improved Street Sweeping Program I alternative and the Improved Street Sweeping Program II alternative, with the alternatives achieving about a 9 to 13 percent reduction in total solids, a 12 to 14 percent reduction in volatile suspended solids, a less than 1 percent reduction in nitrogen, about a 12 to 14 percent reduction in phosphorus, and a 12 to 17 percent reduction in lead.

The evaluation indicates that for the Lincoln Creek watershed, stormwater storage would remove an overall lower percentage of the pollutant loads than would street sweeping. This result occurs because stormwater storage basins appear to be feasible for only a small portion of the watershed, and because those areas that are most feasible for storage basins--those with open land areas--also generate relatively low amounts of pollutants. The Stormwater Storage alternative would be expected to remove from 5 to 10 percent of the total existing loads from the watershed, with the highest removal rates being determined for total solids.

The highest level of loading reduction would be expected for all pollutants except lead, under the Combination alternative, consisting of improved street sweeping and stormwater storage. Pollutant loading reductions under this alternative are about 18 percent in total solids, 17 percent in lead and phosphorus, 16 percent in volatile suspended solids, and 6 percent in nitrogen.

Cost: An economic analysis of the alternative nonpoint source control measures for the Lincoln Creek watershed is set forth in Table V.20. The capital cost and annual operation and maintenance cost is presented for each alternative. To compare the economic aspects of the alternatives, the total present worth and equivalent annual cost of each alternative are also presented. The least

Table V.19

POLLUTANT LOADING REDUCTIONS ANTICIPATED UNDER ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES IN THE LINCOLN CREEK WATERSHED

	Existing	Improved Street Sweeping Program I		Improved Street Sweeping Program II		Stormwater Storage		Combination	
Pollutant	Annual Load (lbs/year)	Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction	Annual Load (lbs/year)	Percent Reduction
Total Solids......	1,508,800	1,367,500	9.4	1,315,600	12.8	1,365,000	9.5	1,237,600	18.0
Volatile Suspended Solids......	179,900	158,350	12.0	154,350	14.2	171,800	4.5	151,200	16.0
Total Nitrogen....	42,120	41,980	0.3	41,940	0.4	39,580	6.0	39,460	6.3
Total Phosphorus..	3,180	2,810	11.6	2,745	13.7	2,995	5.8	2,645	16.8
Total Lead...	3,370	2,950	12.5	2,785	17.4	3,200	5.1	2,800	16.9

Source: SEWRPC.

H0104D/BB

Table V.20

ECONOMIC ANALYSIS OF ALTERNATIVE NONPOINT SOURCE
CONTROL MEASURES FOR THE LINCOLN CREEK WATERSHED

Cost Factor	Improved Street Sweeping Program I	Improved Street Sweeping Program II	Stormwater Storage	Combination
Cost				
Capital Cost.........	$ --	$ --	$298,000	$298,000
Annual Operation and Maintenance Cost....	55,500	119,000	7,600	63,100
Economic Analysis (1983-2003)				
Total Present Worth...	$560,000	$1,200,000	$375,000	$935,000
Equivalent Annual Cost	55,500	119,000	37,100	92,600

Source: SEWRPC.

costly alternative, over the 20-year economic analysis period is the Stormwater Storage alternative, with an estimated equivalent annual cost of about $37,100. The capital cost of the individual stormwater storage basins evaluated would range from $129,000 to $169,000, with a total capital cost of $298,000. The annual operation and maintenance cost of the individual basins would range from $1,200 to $6,400 for a total of $7,600. Cost estimates presented in SEWRPC Community Assistance Planning Report No. 13 were used for Basin A, while the capital cost curve set forth in Chapter IV was used to estimate the capital cost of Basin B.

Under the Improved Street Sweeping Program I alternative, the 563 curb-miles of street which are swept would entail an increased cost of $9,000 per sweeping. A total of nearly 3,400 additional curb miles per year would be swept under this alterantive. Of the total estimated equivalent annual cost of $55,500, about $3,000, or 5 percent, would be for the increased sweeping of commercial streets, and the remaining $52,500, or 95 percent, would be for the increased sweeping of residential and other streets.

Over 7,400 additional curb miles would be swept under the Improved Street Sweeping Program II alternative. Of the total estimated equivalent annual cost of $119,000, $5,000, or 4 percent, would be for the increased sweeping of commercial streets and the remaining $114,000, or 96 percent, would be for the increased sweeping of residential and other streets. The cost of the Improved Street Sweeping Program II alternative is 114 percent higher than the cost of the Improved Street Sweeping Program I alternative.

The Combination alternative has an equivalent annual cost of $92,600, or 22 percent less than the cost of the Improved Street Sweeping Program II alternative, but 67 percent more than the cost of the Improved Street Sweeping Program I alternative. The Combination alternative would also entail a capital cost of $298,000 for the construction of stormwater storage basins.

These costs can be compared to an existing annual cost for street sweeping in the Lincoln Creek watershed of approximately $80,000. The alternative nonpoint source control measures evaluated herein thus are estimated to represent from 46 percent to 149 percent of the existing street sweeping costs.

Cost Effectiveness: Cost effectiveness is a measure of the cost required to remove a unit load of pollutant. For each alternative, the equivalent annual cost per pound of pollutant removed is set forth in Table V.21. The cost effectiveness analysis indicates that for the Lincoln Creek watershed, the Stormwater Storage alternative would be the most cost effective for total solids and nitrogen, whereas, the Improved Street Sweeping Program I alternative would be the most cost effective for volatile suspended solids, phosphorus, and lead. The Improved Street Sweeping Program II alternative would be less cost effective than the Program I alternative for all pollutants. The Combination alternative would be the second most cost effective alternative for all pollutants.

Conclusions: The Lincoln Creek watershed is a good example of a high-density residential area with an existing street sweeping program but with few available sites suitable for the construction of modified detention basins or retention basins. While improved street sweeping would be applicable to nearly all portions of the Lincoln Creek watershed, the potential use of

Table V.21

COST EFFECTIVENESS ANALYSIS OF ALTERNATIVE NONPOINT SOURCE CONTROL MEASURES FOR THE LINCOLN CREEK WATERSHED

	Cost Effectiveness (equivalent annual cost per pound of pollutant removed)			
Pollutant	Improved Street Sweeping Program I	Improved Street Sweeping Program II	Stormwater Storage	Combination
Total Solids...	$ 0.39	$ 0.62	$ 0.26	$ 0.34
Volatile Suspended Solids.........	2.58	4.66	4.58	3.23
Total Nitrogen	396.43	661.11	14.61	34.81
Total Phosphorus....	150.00	274.00	201.00	173.00
Total Lead.....	132.00	203.00	218.00	162.00

Source: SEWRPC.

modified detention basins and retention basins would be severely limited in the watershed. The conclusions of the above analysis are as follows:

1. Improved street sweeping would remove only a modest amount of pollutants--up to 17 percent of the existing loads. As with the Noyes Creek watershed, most benefits would be provided by intensive street sweeping in spring and fall; increased sweeping during the remainder of the sweeping season would provide only slightly improved benefits.

2. The total watershed loads of pollutants which would be removed by stormwater storage basins is much lower than would be removed in either the Noyes Creek or Upper Root River watersheds--less than 10 percent of the existing loads.

3. Because of its limited applicability, stormwater storage would be less costly than an improved street sweeping program implemented nearly throughout the entire watershed.

4. The cost effectiveness of improved street sweeping would be more similar to the cost effectiveness of stormwater storage for this watershed, compared to the Noyes Creek and Upper Root River watershed, where improved street sweeping was substantially less cost effective than stormwater storage.

5. The Combination alternative would provide the highest level of pollutant loading reduction for all pollutants except lead, and is relatively cost effective.

Chapter VI

PUBLIC PARTICIPATION

INTRODUCTION

A public participation program was incorporated into the Milwaukee County Nationwide Urban Runoff Program study in order to meet the following objectives: to inform the public of the purposes, procedures, and findings of the study; to reply to suggestions or problems raised; and to assist in attaining the cooperation of concerned public officials and residents. The public participation program was conducted by the Southeastern Wisconsin Regional Planning Commission in cooperation with the University of Wisconsin-Extension Service, as part of an ongoing regional water quality management public informational program. It was coordinated with the Wisconsin Department of Natural Resources and the public works departments for the Cities of Milwaukee and West Allis. The effort consisted of seven elements, the results of which are summarized below.

COORDINATION WITH PUBLIC OFFICIALS

An important avenue for public participation in the study was made available through the involvement of the appropriate public works officials and agency technicians. This consisted of a relatively small number of qualified individuals highly knowledgeable about public works practices and water quality management, and who were brought together as a technical advisory committee to provide guidance in the design and execution of the study. Just as importantly, however, the members of this group, as listed in Appendix A, provided a means to communicate with key local constituencies about the study, and to coordinate the work locally.

The existing local channels of communication for public works activities thus provided a mechanism for public participation. Appendix B provides one example of how this type of communication occurred, as the City of Milwaukee Department of Public Works prepared a resolution with an attached correspondence explaining the study for consideration by the Milwaukee Common Council. Thus, the local elected officials concerned were made familiar with the objectives and methodology of the study. Additional coordination occurred, with accompanying opportunities for public participation, as the local public works departments were apprised of the scheduled street sweeping and water quality monitoring activities taking place. The correspondence shown in Appendix C provides an example of such coordination.

PERSONAL CONTACTS

The conduct of the study entailed a significant amount of public participation through personal contacts. In anticipation of questions which could be expected during the period of intensive field inventories (see Chapter II of Volume 3), researchers were prepared to discuss the study with residents and proprietors of businesses in the study areas. The result was personal contacts during which the study was discussed with approximately 700 persons who expressed an interest. These individuals constituted that portion of the "public" which was most immediately affected by the study because they lived or worked within the study areas. In addition to the personal contacts made during the field inventories, 20 people living within the study areas were contacted by telephone concerning the possibility of using their respective residences for installation of roof-top devices to obtain samples for water quality analyses. Sampling devices were subsequently installed at three of the residences contacted.

INFORMATIONAL BROCHURES

In order to meet a public educational need, a brochure was prepared in 1980 which briefly described the study and indicated the means by which interested citizens could request additional information. The brochure provided a brief background regarding urban runoff, indicated who would be conducting the study, showed by map location the paired study areas, and described the activities residents might expect to see in their neighborhoods as a result of the study. A copy of the brochure is provided in Appendix D.

This brochure was carried into the field by the researchers conducting the field inventories and distributed to approximately 500 persons who expressed interest in receiving a copy. In addition, multiple copies of the brochure were sent for distribution to the public works departments of the Cities of Milwaukee and West Allis, to the U. S. Geological Survey, and to the Wisconsin Department of Natural Resources. About 30 persons returned a postage-paid, return-by-mail card which was attached to the brochure, requesting more information about the study. These individuals had their names placed on a public information mailing list for the study.

As the study entered its final year, a second brochure was developed to present the preliminary findings of the study to the public. This brochure contained some of the same background information as the earlier brochure, but additionally discussed what had been accomplished in the study to date. A copy of that brochure is provided in Appendix E.

The second brochure was distributed to the mailing list of persons who had earlier indicated a desire for information about the study findings when those findings became available. It was provided to the University of Wisconsin-Extension offices in southeastern Wisconsin and to the Wisconsin Department of Natural Resources for distribution. The brochure was also provided to persons requesting information about urban nonpoint sources of water pollution, and was made available for mass distribution at the public events and presentations as described in the following section.

PUBLIC EVENTS AND PRESENTATIONS

Public participation in the study was promoted within the broader context of the nonpoint source pollution abatement public participation efforts in southeastern Wisconsin as conducted by the Regional Planning Commission in cooperation with the University Extension Service. These efforts have typically included displays at the state and county fairs and other appropriate public forums.

Specifically, the concepts involved in urban nonpoint source water pollution control were included in exhibits placed at the following events during the conduct of the study: the Milwaukee Sentinel Sport Show held in March during the years 1980 and 1982; the Waukesha County Fair held in July 1980; the City of Milwaukee's Small is Beautiful Days celebration held in August-September 1980; and the Wisconsin State Fair held in August during the years 1980, 1981, and 1982.

As previously noted, the informational brochures developed for the study were distributed during the public events listed above. The first brochure was distributed during 1980 and 1981, and the second brochure was distributed during 1982 and 1983. During the course of these events, the brochures and other information regarding urban runoff were at times available to the public through several different avenues. For example, during the 1982 Wisconsin State Fair, the second brochure was distributed in conjunction with a Wisconsin Department of Natural Resources exhibit on nonpoint source pollution during the entire Fair and, additionally, was made available in a separate exhibit area during special "Natural Resources Day" activities.

Information regarding the NURP study was also made available through literature rack displays; and at group presentations varying from elementary and secondary school teachers attending an annual conference focusing on urban environmental issues, to attendees at a regular monthly meeting of an environmental action group.

USE OF THE MEDIA

Both the printed and electronic media were utilized to convey information about the study to the public. An informational news release was prepared in cooperation with staff from the Department of Natural Resources-Southeast District, which was sent in March 1981 to all major media outlets and other interested groups in southeastern Wisconsin. This news release is included as Appendix F.

Major metropolitan area news coverage was obtained as Milwaukee television station WTMJ (NBC Network) ran a short feature pertaining to the study on their evening news program in Spring of 1981. The feature included film footage of street sweeping, vacuum sampling, and water quality monitoring equipment at work in the field, and interviews with staff representing the U. S. Geological Survey, who described the study. The study was also discussed briefly on a segment of WTMJ radio's "Newsmakers" talk show in August 1982, which featured an examination of nonpoint source water pollution in southeastern Wisconsin.

PROFESSIONAL EXCHANGE

In addition to those elements of public participation directed toward study area residents and the general public, the participation efforts included a number of exchanges of information among professionals in the field of water resources. Informed professionals in public service and private industry provide an important linkage with the public. Thus, avenues for the public to become better informed may be opened in conjunction with efforts to inform professionals.

One opportunity for professional exchange occurred through an article regarding the study which appeared in the July 1981 issue of the DNR Digest, an informational publication circulated internally within the Wisconsin Department of Natural Resources to approximately 2,000 employees of that agency located throughout the state. In addition, this publication is distributed to legislators, previous DNR employees, and selected outside agencies. Another opportunity for professional exchange relating to the study was the seventh annual meeting of the American Water Resources Association's Wisconsin Section, which was held during March 1983 in the City of Milwaukee. The two-day meeting was devoted to the presentation of professional papers concerning water-related research in the State of Wisconsin. The event was attended by approximately 150 individuals; and the public was invited to attend via news releases which were sent to all media outlets in the seven-county Southeastern Wisconsin Region. Four professional papers pertinent to the study were presented: "Modeling Nonpoint Pollution Inputs From Eight Watersheds in Milwaukee County," "Sources of Urban Stormwater Pollutants," "The Effects of Street Sweeping on Urban Stormwater Quality," and "Characterization of Urban Stormwater."

At the suggestion of the technical advisory committee, public participation surveys previously conducted as part of the Commission's regional water quality management planning process were reviewed to determine the awareness and perception of the general public as to the impact of urban nonpoint sources of pollution on water quality. The results were summarized in a staff file report, an updated version of which is being used to help guide the preparation of final informational materials. These materials, which will highlight the most important aspects of the completed study, are described in the next section.

FINAL PUBLIC PARTICIPATION PRODUCTS

Because the study involved a technical evaluation and demonstration project which was not designed to culminate with a planning or policy document, the public participation program was directed primarily toward informing key groups about the conduct of the study and gaining their cooperation. The study was not suited for, nor would it have been productive to provide, opportunities for the public to influence the outcome.

Perhaps the most significant opportunity for the "public" or segments of the public to have an impact relative to the study will occur as the findings are applied. A local community evaluating certain public works projects, for example, would now be able to consider the potential effectiveness in abating nonpoint sources of water pollution as a factor in the decision-making process. Accordingly, a number of final public participation products have tentatively been planned for the conclusion of the study. These products are described briefly below.

A water quality edition of the Southeastern Wisconsin Regional Planning Commission-University of Wisconsin Extension Update publication discussing urban nonpoint source pollution controls and the findings of the study is planned to be completed and distributed to persons and organizations on the Commission's areawide water quality mailing list. This distribution has typically consisted of some 2,000 addressees, including many of the citizens most interested in water quality issues in southeastern Wisconsin.

The study will also be summarized in an article contained in the Southeastern Wisconsin Regional Planning Commission Newsletter, a bi-monthly publication with a distribution of approximately 1,500 copies, primarily within, but also extending beyond, the Southeastern Wisconsin Region. Elected officials, agency representatives, and interested citizens comprise the primary audience for this publication.

In order to assist local elected officials and public works departments in their consideration of various techniques for urban nonpoint source pollution control, the preparation of informational materials is being planned to summarize the pollutant removal effectiveness of such practices as street sweeping and stormwater storage systems. These informational materials would discuss the ways in which municipalities could appropriately utilize the above techniques to help abate urban nonpoint source water pollution--recognizing that the primary reasons for communities wanting to conduct street sweeping programs or construct detention basins may be tied to other benefits, such as aesthetics and stormwater management/flood control, respectively.

A final public participation product planned is a news release to be prepared in cooperation with the Wisconsin Department of Natural Resources at the time of final report publication. The news release would describe selected conclusions that were reached, and include appropriate references to end products of the study which are available in printed form and the persons to contact for additional information.

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2-18-80

APPENDIX A

MEMBERSHIP OF SOUTHEASTERN WISCONSIN URBAN RUNOFF PROGRAM TECHNICAL ADVISORY COMMITTEE

INVITED MEMBERSHIP		DESIGNATED REPRESENTATIVE	
NAME	ORGANIZATION	NAME	TITLE
Herbert A Goetsch	City of Milwaukee, Dept. of Public Works	Edwin J. Laszewski	City Engineer
William B. Mann, IV	U.S. Geological Survey	William B. Mann, IV	District Chief
Joel Wesselman	Milwaukee Metropolitan Sewerage Commission	James Meinholz	Group Administrator
Gerald Schwerm	Milwaukee, County, Dept. of Public Works	Fred R. Rehm	Director of Environmental Services
Carl J. Blabaum	Wisconsin Department of Natural Resources	Bernard Schultz	Southeast District Assistant Director
Raymond E. Hahn	City of West Allis, Public Works Dept.	John E. Schumacher	City Engineer
Kent Fuller	U. S. Environmental Protection Agency	Robert Tolpa	Wisconsin National Urban Runoff Program Project Officer
Kurt W. Bauer	Southeastern Wisconsin Regional Planning Commission	Lyman F. Wible	Chief Environmental Planner

Appendix B

RECEIVED
FEB 27 1980
SEWRPC

February 22, 1980

To the Honorable, the Common Council

Dear Aldermen:

Attached hereto is a letter from Mr. Kurt W. Bauer, Executive Director of the Southeastern Wisconsin Regional Planning Commission, dated February 21, 1980. This letter explains a study of urban stormwater runoff which is being proposed by said Commission jointly with the Wisconsin Department of Natural Resources and the U. S. Department of the Interior, Geological Survey. This study is one of 30 being conducted in urban areas throughout the United States, the purpose being to evaluate the effectiveness of street sweeping as a means of reducing pollution from urban storm runoff.

The street sweeping and associated water quality monitoring will occur over a three-year period within ten study areas, eight of which are within the City of Milwaukee and two within the City of West Allis. The ten study areas are paired with each of five study pairs consisting of two sites relatively close to each other and having similar characteristics. The locations of the study sites are shown on the attached map. The project staff has recommended that a private sweeping contractor be retained in order to maintain control over sweeping scheduling, type of equipment, etc. To assure precise knowledge of sweeping activities within the study areas, it is proposed that the City of Milwaukee would not sweep within these areas during the three-year duration of the project. However, the private contractor engaged by the DNR would sweep within the control areas at the same frequency followed by the City of Milwaukee and at greater frequencies within the test areas. In the event of spills or other special needs, the project could provide special immediate sweeping.

Mr. Edwin J. Laszewski is a member of the Technical Advisory Committee for this study.

Inasmuch as this study would serve to improve the knowledge and techniques available to abate non-point source pollution, we believe the City of Milwaukee should cooperate in its implementation. The cost will be borne by the U. S. Environmental Protection Agency and the State of Wisconsin. We have prepared a resolution endorsing the study and authorizing the Commissioner of Public

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To the Honorable, the Common Council
Page 2
February 22, 1980

Works and the City Engineer to cooperate in this study, and to issue the necessary permits to allow the sponsoring agencies to implement their program in the public ways. We recommend adoption of this resolution.

Very truly yours,

Edwin J. Laszewski

Edwin J. Laszewski
City Engineer

Commissioner of Public Works

EJL:WCM:dr

Attachments

FILE NUMBER

Resolution endorsing an urban non-point water pollution management study.

-Analysis-

This resolution grants permission to the Wisconsin DNR and SEWRPC to conduct a water pollution study in the City of Milwaukee.

Whereas, In 1979 the Southeastern Wisconsin Regional Planning Commission (SEWRPC), the designated water quality management agency for this area, completed its Planning Report No. 30, "A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000"; and

Whereas, Said plan recommends that management practices necessary for non-point source pollution control be developed and refined for use by local authorities; and

Whereas, SEWRPC, the Wisconsin Department of Natural Resources, and the U. S. Department of the Interior, Geological Survey (USGS) are now proposing a study to determine more precisely the effectiveness of street sweeping timing and efficiency in reducing non-point water pollution; and

Whereas, Said study will be conducted in certain selected drainage basins in the Cities of Milwaukee and West Allis, and will involve the sweeping of streets in these basins by a private sweeping contractor; and

Whereas, Said study will be funded by the U. S. Environmental Protection Agency and the Wisconsin Department of Natural Resources, and will be a three-year effort; and

Whereas, The sponsoring agencies have requested that a City of Milwaukee representative serve on the Technical Advisory Committee for said study; now, therefore, be it

Resolved, By the Common Council of the City of Milwaukee, that the City of Milwaukee endorses said non-point urban runoff study, to be conducted at no cost to the City of Milwaukee; and be it

Further Resolved, That the Commissioner of Public Works and the City Engineer cooperate in this study and to issue the necessary permits to allow SEWRPC, DNR and USGS to implement their program in the public ways.

Bureau of Engineers
EJL:WCH:dr
2-22-80

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Appendix B (continued)

February 21, 1980

Mr. Edwin J. Laszewski
City Engineer
City of Milwaukee
Municipal Building
841 N. Broadway - Room 612
Milwaukee, Wisconsin 53202

Dear Mr. Laszewski:

Pursuant to your telephone request of February 19, 1980, to Mr. Lyman F. Wible of the Commission staff, this letter is to clarify the intent and recently initiated activities of the study of Urban Stormwater Runoff in Southeastern Wisconsin. The primary purpose of this study, which is being conducted jointly by the Regional Planning Commission, the Wisconsin Department of Natural Resources, and the U. S. Department of the Interior Geological Survey, is to evaluate the impact of increased street sweeping on the quality of urban storm water runoff.

The street sweeping and associated water quality monitoring activities will occur over a three-year period within 10 study areas--averaging about 40 acres each in size--located within Milwaukee County. Of the 10 study areas, as shown on the attached Map 1, eight are within the City of Milwaukee and two are within the City of West Allis. The study areas were selected based on the following criteria:

1. They have relatively uniform land uses representative of developed urban land in Milwaukee County.

2. The storm sewer outlets from the study areas are readily accessible via public rights-of-way to accommodate water quality sampling operations, with the sampling sites usually able to be located in parkways.

3. The study areas are served by separate storm and sanitary sewers, rather than by combined sewers; and are reported not to receive any discharges from sanitary sewage flow relief devices.

4. The study areas are fully developed, with no significant construction activities--and their associated sediment pollution loads--expected to occur within the three-year study period.

The 10 study areas are paired, with each of the five study pairs consisting of two sites relatively close to each other and having similar land cover and drainage characteristics. Six of the areas contain residential land uses and four areas contain commercial land uses. Within each pair, one study area would serve as a "control site" and would be swept at the existing level of street sweeping. The existing level of sweeping is based on information provided by the Cities of Milwaukee and West Allis, and is estimated to be about once every two weeks in commercial areas and about once per month in residential areas. The remaining study area within each pair would serve as the experimental study site and would be swept at increased frequencies--up to approximately three times per week. Water quality sampling would be conducted at the storm sewer outlet from each of the control and study sites. The resulting water quality data would be used to document water quality improvements resulting from increased street sweeping.

To conduct the street sweeping in the 10 study areas, the project staff has recommended that a private sweeping contractor be retained. By using a private contractor to sweep the streets, the researchers will have a high level of control over the necessary sweeper scheduling and variations in sweeper equipment and efficiency related to the specific sweepers used, the speed of operation of the sweeping vehicle, the type and condition of the broom, different operators' work methods, and the operating distance to the curbs. To assure precise knowledge of sweeping activities within the study areas, it is envisioned that the City of Milwaukee would not sweep within the 10 study areas during the 3-year duration of the project. All streets within these areas would be swept by the contractor, at least as often as currently swept by the City, and many streets would be swept even more frequently. In the event of spills or other special needs, the project could, of course, provide special immediate sweeping to handle such emergencies. In addition, other sampling and inventory activities, such as using special vacuum cleaners to measure street surface loadings; measuring rooftop pollutant runoff; and conducting an inventory of the physical characteristics, land uses, and land management activities within the study areas would be conducted by the project staff. As an alternative to using a private contractor to sweep the streets, the City of Milwaukee could itself sweep at the specified frequencies using specific pieces of equipment and specific procedures. While this approach would provide more local governmental involvement in the study, the local flexibility in sweeper equipment assignment and operation by the City Public Works operations would be constrained accordingly.

As expressed at the Technical Advisory Committee meeting held on February 18, 1980, at the Commission offices, your support and cooperation in the conduct of this study is requested. Please indicate whether it would be acceptable to you for the study to utilize the services of a private contractor to sweep streets within the study areas located within the City of Milwaukee. A draft copy of the project work plan, setting forth a detailed description of the study objectives, methods,

Edwin J. Laszewski
Page 3
February 21, 1980

and study areas, was provided to Mr. William Manske of your staff at the Technical Advisory Committee meeting of February 18, 1980.

We trust that this information is helpful to you; and we look forward to your participation in the study, as a member of the Technical Advisory Committee. Should you require further information concerning the study, or wish to meet regarding this matter, please do not hesitate to call.

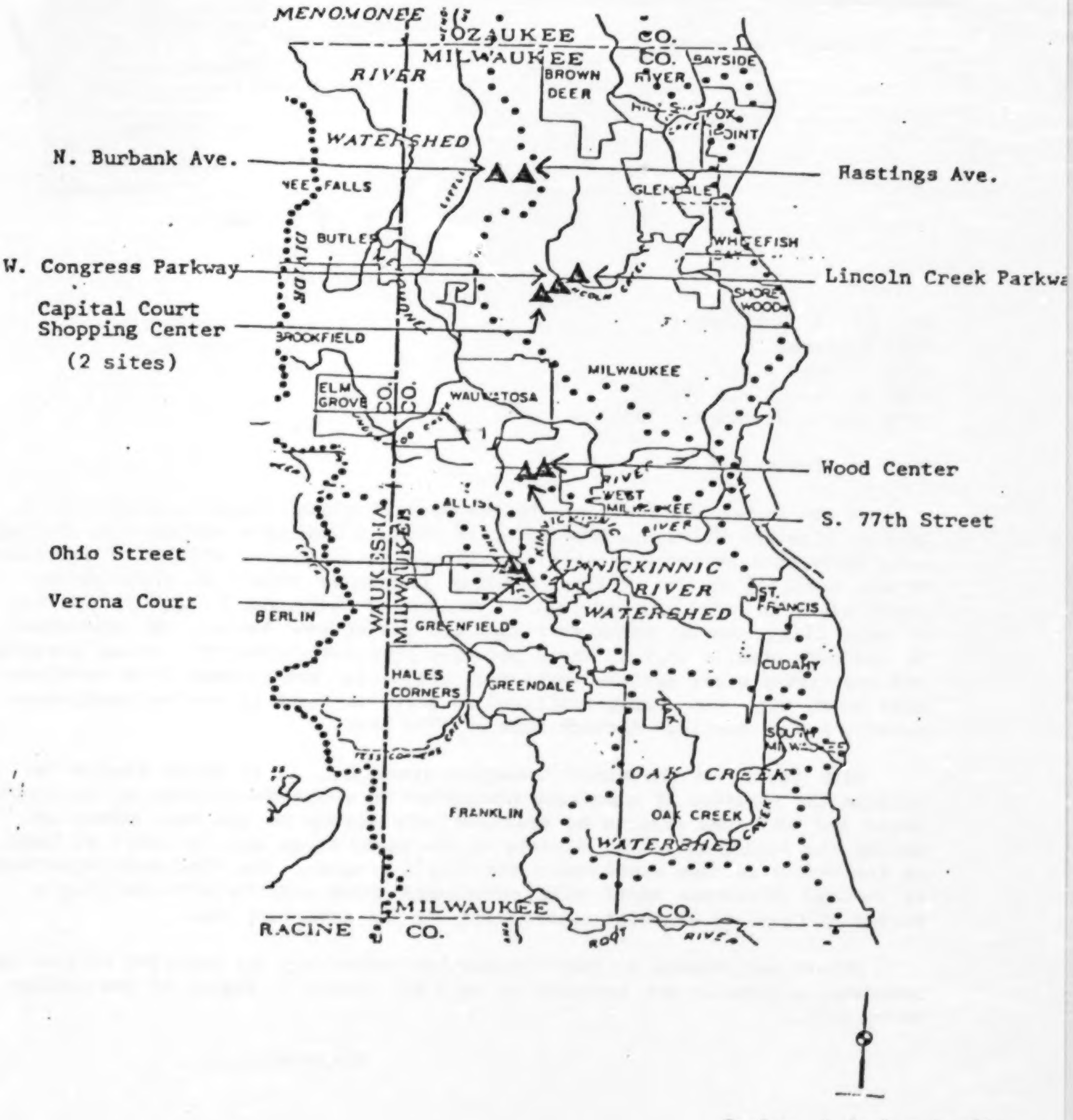
Sincerely,

Kurt W. Bauer
Executive Director

KWB/ea
Enclosure

Map 1

URBAN NONPOINT SOURCE MANAGEMENT STUDY SITES IN SOUTHEASTERN WISCONSIN



Scale: 1 inch = 4 miles

Source: SEWRPC

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Appendix C

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO. EAST AVENUE • P.O. BOX 769 • WAUKESHA, WISCONSIN 53187 • TELEPHONE (414) 547-6721

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

March 3, 1982

Mr. John E. Schumacher
City Engineer
City of West Allis
7525 W. Greenfield Avenue
West Allis, Wisconsin 53214

Dear Mr. Schumacher:

As you know, the Southeastern Wisconsin Regional Planning Commission is working with the Wisconsin Department of Natural Resources and the U.S. Geological Survey on a research project to evaluate the potential effects of increased street sweeping on the quality of urban stormwater runoff at eight paired study sites in Milwaukee and West Allis, two of which are located in the City of West Allis, one at State Fair Park and one at Wood Center. As prescribed in the work plan, a copy of which you have previously received, street sweeping and associated water quality monitoring activities are planned to be continued this year, with work being initiated as early as March if weather conditions permit, and to continue through June of this year.

With regard to the street sweeping operation, it is again planned to utilize the services of a private contractor to sweep the streets in the study areas and that the program be operated this spring in the same manner as during the Spring of 1981. Streets in the study areas will be swept at least as frequently as they would under the City's program. The Wisconsin Department of Natural Resources staff will coordinate these efforts with the City's Bureau of Sanitary District supervisors, as was done last year.

Should you require further information concerning the sweeping program or schedule, please do not hesitate to call Mr. Robert P. Biebel of the Commission staff.

Sincerely,

Kurt W. Bauer
Executive Director

KWB/lb

X

COPY

Appendix C (continued)

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO. EAST AVENUE • P.O. BOX 769 • WAUKESHA, WISCONSIN 53187 • TELEPHONE (414) 547-6721

Serving the Counties of: KENOSHA
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WAUKESHA

July 19, 1982

Mr. John E. Schumacher
City Engineer
City of West Allis
7525 W. Greenfield Avenue
West Allis, Wisconsin 53214

Dear Mr. Schumacher:

As you know, the Southeastern Wisconsin Regional Planning Commission is working with the Wisconsin Department of Natural Resources and the U.S. Geological Survey on a research project to evaluate the potential effects of increased street sweeping on the quality of urban stormwater runoff at eight paired study sites in Milwaukee and West Allis. As prescribed in the work plan, a copy of which you had previously received, street sweeping and associated water quality monitoring activities were initiated in March and continued through June of this year.

This is to advise you that the street sweeping activities and associated water quality monitoring activities carried on as part of this research effort have now been completed in the aforereferenced project areas and the street sweeping contractor working for the Wisconsin Department of Natural Resources will no longer be involved in street sweeping activities in your community.

The cooperation of the City in this phase of the street sweeping study has been greatly appreciated. You will be given an opportunity to review the results of this monitoring work when sample analyses have been completed. Should you desire further information concerning this matter, please do not hesitate to call.

Sincerely,

Kurt W. Bauer
Executive Director

KWB/ib
cc: Mr. Roger Bannerman, DNR

APPENDIX D*

A STREET SWEEPING EXPERIMENT FOR CLEAN WATER

When it rains in the city, dirt, debris and other water pollutants are washed from streets and parking lots into storm sewers which flow directly to streams. Keeping streets clean by sweeping is one way to reduce this water pollution.

There is an experimental street sweeping project going on in selected neighborhoods of Milwaukee and West Allis. Your neighborhood is one of eight being studied in Milwaukee County under the project. The general locations of these study areas are shown on the back of this sheet. The street sweeping project is a cooperative effort of the Southeastern Wisconsin Regional Planning Commission, U.S. Geological Survey, and the Wisconsin Department of Natural Resources. Around the nation, 30 projects of this type are studying various urban land management techniques to control water pollution from storm water runoff. The project has been reviewed and coordinated with city engineers and public works officials of Milwaukee and West Allis.

What will happen in your neighborhood? At various times, street sweepers will be sweeping the streets. They may operate at differing speeds, or at changed times; for example, immediately before a predicted rainfall. Technicians will be testing the amount and quality of storm water runoff draining into the river systems. You may see individuals vacuuming portions of the street to determine what pollutants are on the street before and after the street sweeper has passed by. Field workers will be conducting an inventory of the physical characteristics of the eight study sites. Results of the study should show the effectiveness of street sweepers in preventing pollution from city streets and parking lots from reaching lakes and streams. This study will run for two and one-half years. During that time the experimental street sweeping practices may change in your neighborhood.

Your neighborhood was selected because:

1. Your area is served by storm sewers, and these storm sewers do not carry any storm water which is contaminated by domestic or industrial wastewater from sanitary sewers;
2. Your area is either medium or high density urban development;
3. Your area has an accessible place to sample storm water before it reaches a nearby stream.

If you have questions or suggestions, call Mr. Marc A. Schultz, 547-6721; or write Mr. Marc A. Schultz, University of Wisconsin Extension, P.O. Box 769, Waukesha, Wisconsin 53187. A preprinted inquiry form is attached for your use.

☐ Please send me a summary of the Nonpoint Source Urban Runoff Program findings and recommendations when it is available.

☐ Place my name on a mailing list to receive periodic updates on the progress of the program.

Name ______________________________

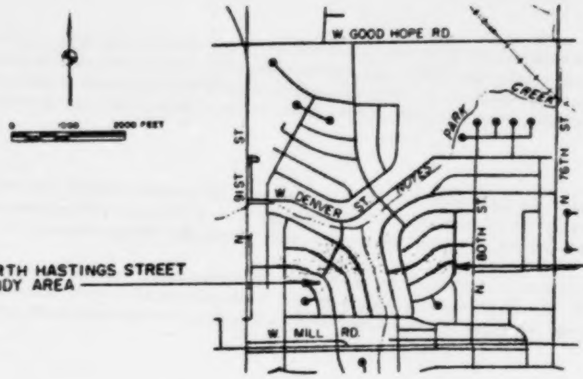
Address ______________________________

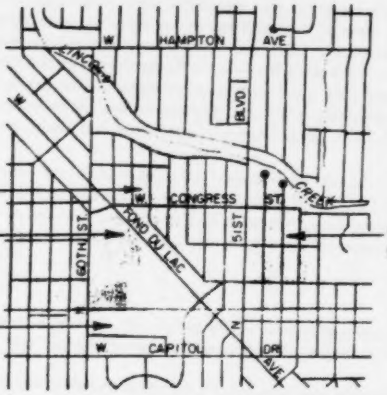
______________________________ Zip Code ________

*Shown 75% of original size.

Appendix D (continued)

NATIONWIDE URBAN RUNOFF PROGRAM
MILWAUKEE COUNTY, WISCONSIN
STUDY AREAS

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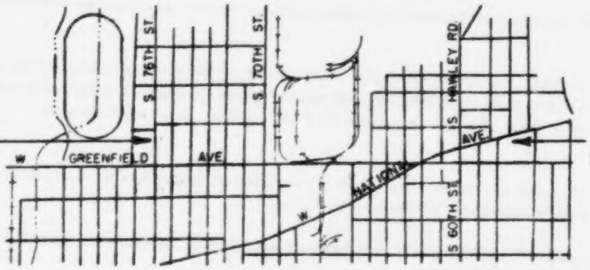
LINCOLN CREEK
W
BLVD
W CONGRESS ST
FOND DU LAC
N AVE
60TH ST
51ST
W CAPITOL DR
WEST LINCOLN CREEK PARKWAY STUDY AREA
CAPITOL COURT NORTH STUDY AREA
~~CAPITOL COURT SOUTH~~ STUDY AREA
WEST CONGRESS STREET STUDY AREA



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ATTN: MARC A. SCHULTZ

APPENDIX E*

STREET SWEEPING AND WATER QUALITY

When rain falls in established urban areas, streets and parking lots are often "washed" and neighborhoods are left looking clean. But the particles and debris washing off these paved surfaces can quickly flow directly into streams and lakes or enter these surface waters by way of storm sewers. Dirt, oil, lead, leaves and grass clippings, fertilizer nutrients, and litter are among the materials washing from streets and parking lots to pollute our surface waters.

In the adopted water quality management plan for southeastern Wisconsin, it is recommended that certain measures be used to reduce the pollutants running off the land with rainfall or melting snow. One of the recommended measures for reducing these pollutants and improving water quality in urban areas is the increased use of street sweeping. In addition to aesthetic benefits and the removal of debris which might otherwise clog storm sewers and contribute to flooding, street sweeping has been shown to reduce some of the potential water pollutants present on city streets.

An Experimental Project

In order to evaluate the effects of street sweeping on the water quality of runoff in urban areas, an experimental street sweeping project was begun during the Fall of 1979 in selected Milwaukee County neighborhoods. In total, eight areas in the Cities of Milwaukee and West Allis were selected as test sites for the street sweeping project. The locations of these areas are shown on the other side of this sheet.

The Milwaukee County street sweeping project is one of 28 studies being conducted across the United States as part of the Nationwide Urban Runoff Program. The project is a cooperative effort of the Southeastern Wisconsin Regional Planning Commission, the U. S. Geological Survey, and the Wisconsin Department of Natural Resources. It has also been coordinated with the City Engineers and public works officials for the Cities of Milwaukee and West Allis.

What Has Been Done So Far?

Within each of four pairs of neighborhood study areas, one area was designated as a "control" area and the other was designated as a "test" area. The frequency of street sweeping in the "control" areas was the same as would normally be maintained by the City of Milwaukee, or the City of West Allis. Beginning in May 1980, the frequency of street sweeping in the "test" areas was varied under the project. At times, streets and parking lots in the test areas were swept at the same frequency as in the control areas—at other times the test areas were swept more frequently. Vacuum cleaners were used to sample the materials present on paved surfaces before and after street sweepers passed by. Water quality samples from each of the neighborhood study areas were collected at their storm sewer outlets during rainfall events. In addition, information was gathered by field workers who conducted an inventory of the physical characteristics present in the neighborhoods.

The street sweeping and water quality sampling portion of the project was completed in June 1982. Technicians are now continuing to analyze the inventory data and many samples collected during the project to determine the quality and amount of storm water runoff draining from the neighborhood study areas into their respective river systems. Their primary objectives are to characterize the extent and sources of urban storm water pollution, and to discover what, if any, difference there is in the water quality of the runoff as a result of increased street sweeping in the test areas.

Some Preliminary Findings

The following are preliminary findings based upon an analysis of the initial street sweeping data and water quality samples gathered under the Milwaukee County street sweeping project. The analysis of additional data and samples will help to clarify these findings in the near future:

1. Urban storm water runoff was found to be heavily polluted with metals including lead, zinc, copper, cadmium, and iron which may be toxic to aquatic life—or to humans if such pollutants were present in drinking water supplies.

2. Smooth streets, or streets in good condition, have much lower amounts of pollutants associated with them than rough streets, or streets in poor condition.

3. Neighborhoods with heavy traffic patterns (commercial areas) generally have higher amounts of lead and other particles that have accumulated on paved surfaces; while neighborhoods with extensive areas of grass and trees (residential areas) have higher amounts of vegetative debris such as lawn clippings and leaves on paved surfaces, along with associated nutrients such as nitrogen and phosphorus.

4. Medium density residential areas and parking lots generally have lower concentrations of most pollutants present on paved surfaces than either commercial areas or high density residential development.

5. The amounts of pollutants which accumulate on street surfaces are generally highest in the early spring prior to the onset of spring rains, and when leaves drop from trees in the fall.

6. The efficiency of frequent street sweeping in improving the quality of storm water runoff from paved surfaces in the Milwaukee County study areas appears to be variable. Street sweepers were shown to remove a portion of the pollutants such as lead, particles, and fertilizer nutrients from streets and parking lots. However, additional data will need to be analyzed before any firm conclusions are made regarding the overall effectiveness of street sweeping as a measure to improve water quality in urban areas of southeastern Wisconsin.

For More Information . . .

about the Milwaukee County street sweeping project or other water quality issues in southeastern Wisconsin, contact:

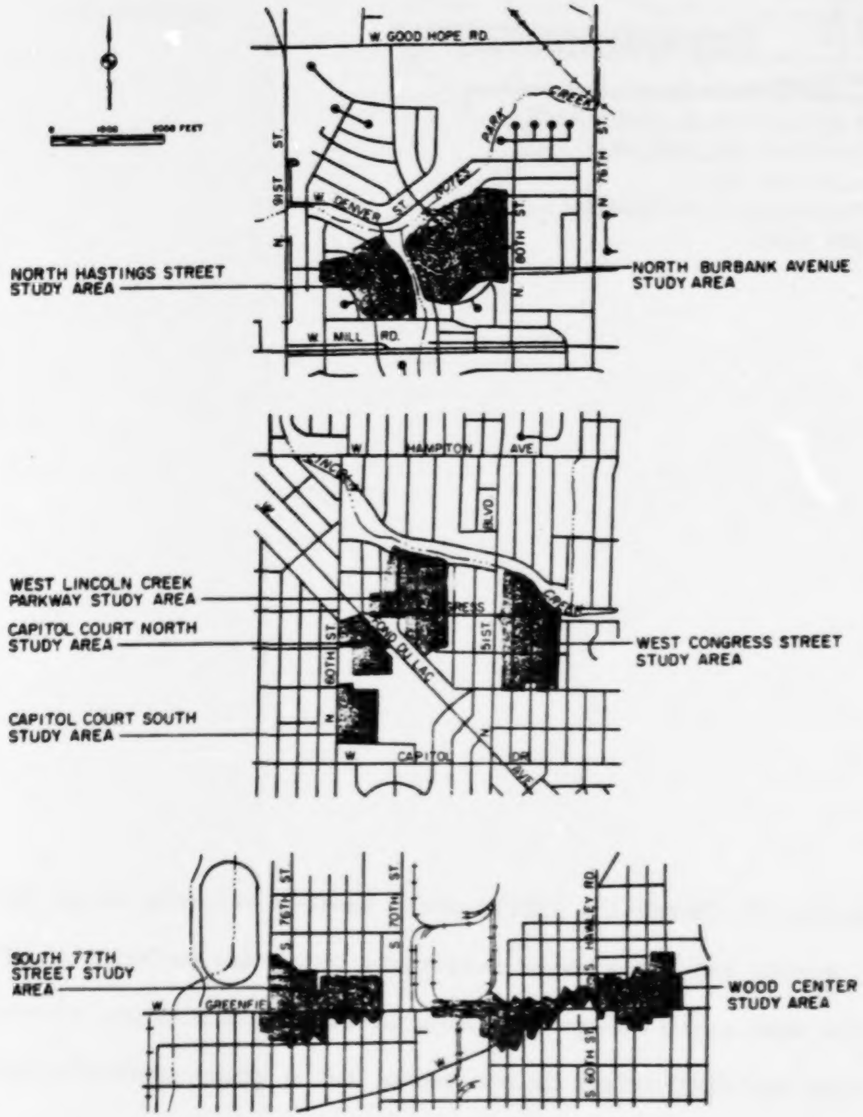
Gary K. Korb
UWEX Natural Resources Agent
Southeastern Wisconsin Regional Planning Commission
916 N. East Avenue, P. O. Box 769
Waukesha, Wisconsin 53187

Phone: (414) 547-6721

*Shown 75% of original size.

Appendix E (continued)

NATIONWIDE URBAN RUNOFF PROGRAM
MILWAUKEE COUNTY, WISCONSIN
STUDY AREAS



How Were the Neighborhood Study Areas Chosen?

The neighborhood study areas involved in the Nationwide Urban Runoff Program through the Milwaukee County street sweeping project were chosen for the following reasons:

1. The neighborhoods are served by storm sewers, and these storm sewers do not carry any runoff water which is contaminated by domestic or industrial wastewater from sanitary sewers;

2. The neighborhoods represent four different types of urban development: commercial development along major streets, high density residential development, medium density residential development, and parking lots;

3. The neighborhoods could be clearly divided into paired study areas which are either adjacent to, or within a quarter mile of each other;

4. The neighborhoods are small, making them relatively easy to work with—the largest study area is less than 63 acres;

5. The neighborhood study areas each have an accessible place to sample the storm water runoff coming from their respective streets and parking lots before it reaches a nearby stream.

INFORMATION

DEPARTMENT OF NATURAL RESOURCES
SOUTHEAST DISTRICT HEADQUARTERS
9722 WATERTOWN PL. RD.
BOX 13248, MILWAUKEE, WISCONSIN 53213
PHONE (414) 257-6543

APPENDIX F

MILWAUKEE, WI (March 10, 1981)--April showers not only bring May flowers but also dirt, debris and other water pollutants which are washed from streets and parking lots into storm sewers that flow to Wisconsin's lakes, rivers and streams. Just how much and what affect is not known, but a study currently underway in the Milwaukee area just might provide some answers.

The $1 million study, part of the Nationwide Urban Runoff Program, will study the affects of street sweeping in helping to control urban non-point source runoff pollution. Four test and control sites have been established, representing commercial, industrial and residential urban areas, according to Mark Sesing, Water Quality Environmental Specialist for the Department of Natural Resources.

MORE MORE MORE

Begun in January, 1980, the project is being sponsored by the U.S. Geological Survey, Southeastern Wisconsin Regional Planning Commission, U.S. Environmental Protection agency and the DNR. The study will run through 1982, and the results will be compiled with the results of 30 other studies underway across the nation. The fundings will be combined to provide a package for the U.S. Congress to control urban non-point runoff in urban areas. Studies being done in other parts of the country include construction site erosion control and the affects of air pollution fallout on urban runoff.

In each of the four study areas, the control site will receive normal sweeping and the test areas will receive more frequent sweeping. Sampling will be done by monitoring the runoff from rainstorms and snow melts where the storm sewer discharges into the river. Street samples are also being taken to determine what type of dry particulate matter will run off.

The four study areas are Capitol Court parking lot, Lincoln Creek between Hampton Avenue and Capitol Drive, Noyes Park near Good Hope Road and portions of the City of West Allis. Milwaukee is the only area being studied on how winter conditions affect street sweeping.

"Data results are not in yet," said Sesing. "But based on past studies in Milwaukee and other areas, we expect to find high levels of organics such as oil and grease, metals such as lead and nutrients such as phosphorus." Sesing also noted that his testing shows high levels of oxygen demand and suspended solids during periods of high runoff than during periods of dry weather.

MORE MORE MORE

"When our study is added with those studies being done elsewhere, we should have a pretty good idea what steps should be taken to control urban non-point runoff. We just may find out that it is more economical to prevent water pollution from non-point sources than to try to clean up our waters afterwards," added Sesing.

-30-

CONTACT:

Mark Sesing
Water Quality Environmental Specialist
(414) 257-6936

or

John Nelson
Public Information Officer
(414) 257-6945

3-10-81
bg